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MSS. intended for publication and books, etc., intended for review should be sent to Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

GENERAL PROBLEMS AND TENDENCIES IN CANCER RESEARCH[1]

AFTER the successful continuous transplantation of rat sarcoma and mouse carcinoma had shown that we possessed a method suitable for the study of the biology of tumors, and which promised a rich harvest of results, the decade following the year 1901 was to a great extent devoted to the study of propagated tumors rather than to the analysis of the first origin of tumors, although this latter problem had never been entirely neglected. Within recent years, however, much attention has been given to the origin of tumors. The so-called endemic occurrence of cancer which we observed in the case of cattle and rats, and which certain investigators noted in the case of mice and other animals, suggested to us sixteen years ago the possible significance of heredity as an etiological factor. Some years later, observations which we made in a mouse-breeding establishment in Granby confirmed this hypothesis; but it is only during the last six years, following the observations of Tyzzer and Murray, that our investigations, carried out in conjunction with Miss Lathrop, proved on a very broad basis the very great significance of heredity in the transmission of cancer in mice, the partial independence of the age and frequency factors, and the correlation between cancer frequency and structural and functional characteristics of the animal. The results of hybridization experiments which we carried out on a large scale indicate that in some crosses the tendency to a high

[1] An address before Section VIII. of the II. Pan-American Scientific Congress on January 5, 1916.

cancer rate may be dominant, while in some others the opposite tendency predominates, and in a few an intermediate result is obtained. Our experiments established for the first time the cancer rate for a number of different strains; each strain was followed through several successive generations and in each generation a large number of animals were observed. The resultant figures for the various generations of the same strain were usually in fairly close agreement. Animals belonging to such strains were used for hybridization experiments. The results of hybridization experiments which we obtained do not seem to be compatible with the view recently expressed that the tendency to cancer is a recessive character and that all results can be explained on such a basis.[2]

Of a different character is a problem in heredity first studied by E. E. Tyzzer. It is well known that some strains of mice are a favorable soil for a certain transplantable tumor, while other strains are not. In crossing a favorable and an unfavorable strain Tyzzer found conditions apparently incompatible with Mendelian principles. We obtained likewise in subsequent experiments with M. S. Fleisher, results similar to those of Tyzzer, and we suggested that the results might be explained by assuming the presence of multiple factors. The same interpretation may apply to the heredity of autochthonous tumors to which we referred above and in which also simple Mendelian proportions do not seem to exist.

These studies of the cancer incidence in various strains of mice and the methods used therein have, however, a much wider significance. On the basis of a thorough knowledge of the cancer incidence in certain families, and on this basis alone, will it be possible to analyze certain other factors in the etiology of tumors, and the understanding of these latter factors, as well as of heredity, will perhaps ultimately provide us with a rational basis for the prevention of cancer. Without a thorough knowledge of heredity, conclusive results as to the significance of other factors could not be expected. Acting on this principle, we found that castration in sexually mature mice at the age of three to eight months reduces the cancer rate in a very pronounced way. Prevention of pregnancy, while it still has some effect in reducing the cancer rate, as we found several years ago, has very much less significance than castration.

These results and some additional ones to be mentioned shortly permit us to classify the causes of tumors into two main divisions, internal and external ones. Heredity belongs to the former class. The point of attack of these hereditary factors we do not yet know. In some cases, they may perhaps stand in relation to some other internal factors, which are in all probability of significance in certain cases. I refer to the spontaneous parthenogenetic development of the egg within the ovary and elsewhere in mammals, a process which, according to our findings in the guinea pig, is not a rare occurrence, and may even normally proceed to the formation of the anlage of the central nervous system. To this class of factors may also belong developmental errors which were already suspected by Cohnheim and which as we know may appear as inheritable mutations in various groups of animals.

The external factors may be further divided into chemical and mechanical, and both may be derived either from within the body or from the outside world. As an example of a chemical factor originating within the body, we may cite the great importance of the internal secretion of the

2 Maud Slye, *Interstate Medical Journal*, XXII., July, 1915, p. 692.

corpus luteum in the origin of cancer in mice to which we referred above, but other internal secretions will probably be found to be of similar significance. External mechanical factors can be recognized in the well-known effect of chronic irritation. How far certain parasites, especially those in the class of vermes and insects, produce cancer through chemical and how far through mechanical means is not certain. Previous observations in man in the case of cancer of the bladder caused, directly or indirectly, by bilharzia, and especially the recent experiments of Fibiger make it, however, quite certain that such parasites may be the cause of cancer. It is likewise uncertain how far Roentgen-ray cancer, frequent in Roentgen-ray operators, and also apparently experimentally produced in a few rats by Marie, is due to ulceration subsequent to exposure to or to the direct stimulating action of the rays. In some cases perhaps chemical and mechanical factors may cooperate in producing tumors; the efficiency of such a combination in calling forth tumor-like formations has been shown by us in the case of deciduomata of the uterus, which we produced experimentally, a new formation which we included in a class designated as transitory tumors.

There are observations on hand which indicate that growth stimuli may be especially active in animals with a hereditarily determined tendency to cancer. Such an observation we made in the case of a cancer in a mouse belonging to a family rich in tumors, where ulceration of the skin near an adenoma of the mammary gland led to the development of an epidermal carcinoma. Further systematically conducted experiments in this direction might lead to interesting results.

It is, however, not probable that in order to obtain the production of cancer there must be a definite quantity of prerequisite internal factors. On the contrary, there is some evidence on hand which makes it probable that internal and external factors may vary in inverse ratio, and that if the external factors are quantitatively very strong, the quantity of internal factors may be reduced.

If we survey briefly the various types of growth reactions known in vertebrates, we may perhaps, according to the character of the stimuli, which are usually in each case the first members in a complicated reaction chain, and according to the character of the systems on which they act, provisionally distinguish the following types:

1. Various stimuli act for a short time on complex systems, the egg-cells, and lead to a long chain of growth phenomena which ultimately cease. The experiments in artificial parthenogenesis of Jacques Loeb led to a very far-going analysis of these phenomena.

2. Defects lead to a chain of growth phenomena, which are of a temporary character, and which come to a standstill after a certain quantity and kind of new-formed tissue has more or less completely filled out the defect.

3. Chemical substances stimulate the growth of certain tissues to which they bear a more or less specific relation. These growth phenomena come to a standstill with the activity of the stimulating substance or very soon afterwards (corpus luteum and mammary gland).

4. A combination of factors 2 and 3 may lead to tumor-like growth phenomena when either factor alone would cause only a slight proliferation. Here again the effect is temporary (experimental deciduomata of the uterus).

5. Chemical (fat soluble?) bodies which do not show a specific relation to the organs affected stimulate various tissues to a temporary proliferation; fat soluble stains

(Bernhard Fischer and others) and ether (Reinke) are substances that under certain conditions seem to exert a stimulating effect.

6. Chemical and mechanical factors produce with the aid of a large quantity of internal factors, or in certain cases apparently without such aid, an increase in cell proliferation that persists after the stimuli have ceased, which is permanent, potentially of unlimited duration in contradistinction to the temporary reactions mentioned above. This is the cancerous reaction with which all or at least the large majority of the mammalian tissues may respond. Neither potential immortality—some, or perhaps all, somatic cells are potentially immortal—nor the power of continued proliferation, which in all probability even certain ordinary somatic cells possess, is characteristic of this reaction, but rather the increase in proliferative power, and furthermore the permanency of the reaction in response to a temporary, non-permanent stimulus. We have then to assume that a labile cell-system which responds to temporary stimuli with a temporary reaction is transformed under the influence of certain stimuli, and often with the aid of hereditary factors, into a stable system which shows a greater proliferative power than the labile system. The stimulus thus brings about merely a transformation of the cells into a new kind of cell-system, which proliferates indefinitely at a more or less increased rate. Such a transformation may be called a mutation.[3] Inasmuch as all, or the large majority of all body cells are liable to this change, they must have from the beginning in their organization a mechanism that provides for the possibility of such a mutation.

[3] We would have to deal in this case with a mutation, not in a germ cell, but in a somatic cell. For a more detailed discussion of this problem *cf.* Leo Loeb, "Germ Cells and Somatic Cells," *American Naturalist*, Vol. 49, 1915, p. 286.

According to this conception, we must then assume that all or most cells have potentially two equilibria, the normal one and the cancerous; they begin life with the normal equilibrium, but under the influence of certain stimuli, with or without the cooperation of hereditary factors, they are transferred to the cancerous equilibrium.

Cells in the normal equilibrium react to stimuli in the manner indicated above (types 1 to 5); ultimately they return invariably to the normal equilibrium after the stimulus has ceased to act. Cancerous cells, on the other hand, may perhaps be exterminated, but they are not known to return to the normal equilibrium.

There is, however, an alternative to this conception which would eliminate the necessity for assuming a new equilibrium for cancerous proliferation, an assumption for which naturally no analogy can exist. If we assume that an external agent associated with the cell, rather than a physico-chemical mechanism within the cell, produces the cancerous proliferation, the latter would no longer represent a unique condition, but would be a special application of one of the types 3 to 5, in which, however, the stimulus would act incessantly. Such a stimulus could be supplied through multiplying microorganisms which essentially represent constantly newly formed external chemical stimuli. Such microorganisms would not be identical with bacteria causing various ordinary infectious diseases. As we have shown at an early stage of our investigations, cancer among animals is not infectious in the sense in which certain other diseases are infectious. We could feed tumor tissue to normal animals or keep normal animals in the same cage with cancerous animals without a transfer of the disease taking place; neither could Ehrlich produce cancer in young mice which were suckled by cancerous animals. But this does not

exclude the possibility that certain other organisms might play a certain rôle. We know that microorganisms can call forth cell multiplication in plants and animals. In plants, certain bacteria can produce, as has especially been demonstrated in the case of the crowngall by Erwin F. Smith, tumor like proliferation—a result depending in this case not merely on the kind of stimulus, but also on the particular system on which the stimulus acts. In this connection we might also mention a number of extremely interesting cases in which various investigators saw the transformation of normal into cancerous tissues, subsequent to contact with cancerous tissue of another kind, but in the same individual. I referred above to an observation of this character in which we found skin to become cancerous under the influence of an adenocarcinoma of the mammary gland. Similarly, in contact with carcinoma, connective tissue may become sarcomatous. Such tumors we called combination contact tumors. In such a carcinosarcoma in a Japanese mouse which we studied experimentally, we found that the carcinomatous and sarcomatous components followed the same variation curve of growth energy in succeeding generations. This suggests the identity of the agent which causes the proliferation of both tissues and the dependence of the variation in growth upon the variation in the activity of the agent. The agent transferred from one tissue to another might be a chemical substance—an explanation first suggested in the case of the sarcomatous transformation of the stroma by Ehrlich and Apolant—or it might be a microorganism. Even under normal conditions there are indications which point to a chemical influence exerted by one tissue upon another. In this manner we interpreted the difference in cell activity in the connective tissue of the mucosa in certain organs near the epithelium on the one, and near the submucosa on the other hand. The different effect exerted by the tissues of different individuals upon the activity of the fibroblasts of the host also points to such a conclusion (different effects of auto- and homiotransplantation).

The very important results of Peyton Rous are worthy of especial consideration. This investigator, working with fowls and employing methods which in the case of mammalian tumor had not led to positive results in the hands of earlier investigators, was able to separate by filtration and other means the causative agent from the sarcoma cells with which it was associated. In this case, we might have to deal either with filterable microorganisms, or again with chemical substances. If we accept the latter alternative, we would have to assume that the same substance that initiated the cancerous cell proliferation in normal cells would, after the change has once been accomplished, be perpetually newly formed within the proliferating cells. This condition would in some respects be comparable to an autokatalytic process.[4] The cancerous equilibrium would represent a condition in which this growth substance is either produced in a larger quantity than it exists in normal cells, or is entirely formed de novo. It seems furthermore that no antibody is produced in the body-fluid against this substance. These substances do not seem to be separable from the cells in all fowl tumors, and the kind of fowl tumors in which a separation can not be accomplished behave in this respect like the mam-

[4] Certain analogies between growth curves and autokatalytic processes have formerly been pointed out by Jacques Loeb, W. O. Ostwald and T. B. Robertson. In the case of fowl tumors we would have in addition to deal with the new formation within the tissue cells of a substance carried to the tissues from the outside.

malian tumors. We would have to assume the existence of different substances of this kind, and different substances always call forth a specific activity of connective tissue cells resulting in the reproduction of the original kind of tumor, and stimulating endlessly the production of the same specific substance within the fibroblasts. Just as in the case of the corpus luteum substance which is responsible for the production of deciduomata, the cooperation of a mechanical factor seems to be essential for the stimulation of tumor growth in fowl. We would most probably have to give this interpretation to these phenomena if the observation of Casimir Funk, according to whom an alcoholic extract of the tumor contains the active agent, could be confirmed in a larger number of cases. If this should prove correct, we may expect to find corresponding conditions in mammalian cancer. A study of heredity in cancer of the fowl would close this chain of investigations, and with the analysis of internal and external factors in cancer already on a solid foundation, we could then conclude that the causes of cancer in their main outline have been satisfactorily analyzed. Of course underneath this first plane of causes there are connections which extend further into fields where they meet with other factors determining cell and tissue life in its dependence upon physical and chemical laws, and thus we are led into deeper planes of causation. But here the problems have become identical with those of general biology, the laws governing cell division and ameboid movements in cancer cells not differing from those of other cells.

In this connection a few words concerning the definition of cancer might not be out of place. It might indeed be assumed that a definition of cancer satisfying past and future research is one of the essential requirements for the fruitful pursuit of investigation. On the contrary, I believe that at the present stage of investigation progress may be retarded through premature rigidity in defining cancer, and especially through insisting on the proof that secondary tumors originate from transplanted cells. In the case of sarcoma of the rat and mouse, this proof has so far been supplied only in the rat sarcoma of the thyroid found in Chicago, and is merely based on analogy in the case of the large majority of other sarcomata. Since it has now been shown that in sarcoma of fowl an agent associated with the tumor, but separable from it, may just as well give origin to new growths, we may well hesitate in excluding from consideration new formations which in all probability under certain conditions have their origin in transplanted cells, while in other cases they may perhaps be propagated through an agent associated with the tumor. I refer here especially to the so-called lympho-sarcoma or small round cell sarcoma of dogs which, after transplantation in dogs, apparently grows from the transplanted cells (Sticker, Ewing and Beebe, and L. Loeb), while in the fox, according to von Dungern, the tumor cells are composed of host tissue. May we not, in case von Dungern's view should prove correct, have to consider the possibility that the transplanted dog cells perished in the foreign species, and that the associated agent stimulated the host cells to proliferation?

With the factors which we have already analyzed—factors of heredity, of internal secretion, of external, chemical and mechanical stimulation—we are in a position to control to a great extent the cancer rate in certain species of animals. As we said, we can not yet exclude with certainty the other alternative, namely, microorganisms, as an additional causative factor.

After so many futile attempts to establish a direct proof of their presence, further

efforts of this kind do not appear promising at present. There seem, however, still other ways open through which one may approach this problem in an indirect manner.

To decide between the two alternatives which we mentioned does not only concern cancer research in the more restricted sense, but is of the greatest importance for general biology. In return for much that it received from neighboring sciences, cancer research has given something important to biology; the serial endless experimental propagation of tumors has enriched biology with a valuable instrument of research and new outlooks on the life and character of somatic cells have been gained. We may briefly mention the following facts established or very strongly suggested: In the course of our early transplantations, we found that the energy of tumor growth can be experimentally increased as well as decreased. Ehrlich explained the increase as due to a selection of rapidly growing tumors; we, however, believed from the beginning that it was partly produced by a mechanical stimulation of the tumor cells and in addition was possibly due to chemical stimulation caused by the transfer into a new host with a different constitution of the body-fluids; in some cases perhaps processes of immunity may also enter into this phenomenon.

In conjunction with M. S. Fleisher, we noted that chemical bodies which inhibit tissue growth at a certain period in the life of tumors do not have this power at other periods. Especially are they powerless in the case of very young tumors, an observation confirmed by Keysser. But we found that such early injections produce an immunization against the later action of these substances. The proof thus given that an immunization takes place against substances (and apparently also against physical agencies) inhibiting tumor growth is, as we pointed out on previous occasions, of great importance in our attempts to arrive at a rational treatment of cancer. Our experiments suggest, furthermore, very strongly that this immunity is of a twofold character, that it originates in the host as well as in the tumor cells themselves; that this cell immunity can be transferred to a certain number of later cell generations and is to some extent specific for the substance which had called it forth. While our results, based on the observation of a very large number of animals, strongly suggest these latter conclusions, we nevertheless think it desirable to add new evidence in order to guard against a complication with variable factors.

Are we in all these cases dealing with indirect actions on the cells and with direct actions on accompanying microorganisms, or with direct actions on the cells? We rather incline to the latter view and we would suggest that an increase in chemical activity in the tumor cells—an increase perhaps restricted to certain activities—renders the latter a much finer balance in their response to certain environmental conditions through variations in growth energy than are the normal tissue cells.

As we pointed out in 1901 on the basis of Morau's and our own experiments, cancer cells are potentially immortal in the same sense in which Protozoa and germ cells are potentially immortal. All, or at least the large majority of all normal tissue cells are potentially cancer cells, and we may therefore with full justification conclude that ordinary somatic cells are likewise potentially immortal. Like the majority of tumors, they can not be indefinitely propagated in other individuals of the same species because of the injurious action of what we may term homoiotoxins. On the other hand, thanks to their increased growth energy and perhaps a lessened sensitiveness

to homoiotoxins, the cells of certain tumors can overcome the injurious conditions existing in other individuals of the same species and be propagated indefinitely. Tumor cells and ordinary tissue cells do not differ in potential immortality (as Bashford and others assumed), but in the intensity with which they proliferate and in their destructive power.

Of equally great biological interest are the defensive reactions called forth in the host through the growth of the tumor cells. As one of the most important results, we may here state that no immunity seems to be produced through tumor growth in the animals in which the tumor originated. We found that in the case of rat and dog tumors, cells remained alive and grew after transplantation into the animal in which they originated, while they died in other individuals of the same species. Tyzzer found the same to be true in the chicken, and Haaland and Fleisher and ourselves in the mouse. Haaland's experiments suggested, furthermore, that the autochthonous tumor could not act as antigen and by proving in addition that this tumor does not neutralize immune substances, our experiments prove the correctness of Haaland's suggestion that against an autochthonous tumor no immunity can be produced. The greater significance again attached to the study of animals in which tumors originated in contradistinction to bearers of experimental tumors, is one of the characteristic tendencies of recent cancer investigation, and it is of interest in this connection to note that our experiments indicate that animals with autochthonous tumors are a better soil for the growth of other spontaneous tumors than normal animals.

While therefore in the organism in which the tumor originated usually no reaction takes place against tumor cells, reactions do take place after transplantation of tumor cells into other individuals. These reactions are essentially of a similar character in the case of tumors and of normal tissues. Again correlation between the behavior of normal and of cancerous tissues has proven fruitful of results in this case. After autotransplantation of a piece of normal tissue, it may in the same way as a piece of tumor, at least in the case of certain tissues, apparently live indefinitely, while after homoiotransplantation, as we observed, the tissues die as a result of the attack by lymphocytes and through the influence of fibroblasts of the host which produce dense fibrous tissue which in turn strangulates the foreign cells. There is a possibility that the strange body fluids may also directly interfere with the metabolism of certain transplanted tissues to such an extent as to severely injure them. After heterotransplantation the indirect injurious action of the body fluids, which are unsuitable for the metabolism of the transplanted cells, is more pronounced and leads to the early death of the transplanted cells. We found in the case of skin under these conditions no noticeable activity on the part of the lymphocytes and fibroblasts. J. B. Murphy, however, recently showed through very ingenious experiments that in the case of heterotransplantation also lymphocytes, under certain conditions, may be of importance as a defensive mechanism of the host.

It has likewise been shown by such investigators as Burgess, DaFano, Baeslack, Rous and J. B. Murphy, that in the case of tumors against which an immunity becomes established, lymphocytes sometimes, in conjunction with other leucocytes, play a distinct rôle in the destruction of the tumor tissue. This holds good in the case of tumors already established. If immunity is produced before the transplanted tumor has united with the host tissues, the ingrowth

of fibroblasts and blood vessels into the transplanted tissue may, according to Russel and Woglom (in the case of tumors) and Peyton Rous (in the case of embryonic tissues) be delayed or else diminished in amount. However, even in the latter case the defence of the organism against the foreign tumor cells may principally consist in an attack by lymphocytes and other leucocytes (E. E. Tyzzer).

As the most probable explanation for these phenomena, we have proposed the following theory:[5] The mutual chemical incompatibility of the body fluids of one individual and the tissues of another, which we could especially clearly demonstrate after homoiotransplantation of pigmented skin, leads to changes in the metabolism of the tissues, resulting in the production of homoio- and heterotoxins, which if they do not exceed a certain strength, disturb the normal functions of the transplanted tissues to some extent without, however, interfering seriously with their life. But the abnormal products formed attract the lymphocytes and in certain cases also other leucocytes, and alter the reaction of the fibroblasts, which latter are induced to produce dense fibrous tissue. If the poisons become more active, they may directly injure tissues to such an extent that growth and life become impossible.

These conclusions, as we believe, also throw light on so-called chronic inflammatory processes of various organs where a changed metabolism of the cells, and perhaps also poisons produced by microorganisms, may induce fibroblasts to form fibrous bands and attract lymphocytes, thus leading to processes of cirrhosis. In a similar way, in the case of tumor immunity, which, for instance (as Clowes and Gaylord have shown), exists in the case of the retrogression of tumors, substances produced as a result of immunization and which circulate in the body fluids alter the metabolism of the tumor cells, which in turn influence the activity of the lymphocytes and fibroblasts in a way similar to normal tissues in a strange host. This theory correlates the immunity against tumor and tissue growth with the immunity against certain substances and non-growing foreign cells. We have also in the former case to deal with the production of immune substances, which, however, in the case of homoiotransplantation, are usually not such that they directly destroy the foreign tissues, but merely lead to an alteration of their metabolism and to the production of substances which change the behavior of the host cells. We no longer need to assume a primary tissue alteration following the homoiotransplantation.

It remains for further investigations to decide to what extent the presence of foreign tissue leads to the direct production of what we could call primary homoio- and heterotoxins as the result of the interaction between the preformed constituents of the body-fluids and the foreign cells, and to what extent it leads to the production of secondary homoio- and heterotoxins—the immune substances—as the result of immune reactions. At present it appears probable that both these substances play a rôle. In vitro the toxicity of body fluids of foreign species is apparently not very marked, as we, as well as Lambert, found. The toxicity is certainly less than we should expect, considering the fate of tissues after heterotransplantation. We must, however, take into account the fact that the amount of body fluid and especially of toxin acting on the tissue in vitro, is extremely small as compared with the quantity acting in the

[5] Leo Loeb, "The Influence of Changes in the Chemical Environment on the Life and Growth of Tissues," *Journal American Medical Association*, Vol. 64, February, 1915, p. 726.

living body, and that this reduction in the quantity of body fluid is very much greater than the reduction in the quantity of tissue. Furthermore, in the body the fluid in contact with the tissue is constantly renewed and the old fluid is eliminated. In vitro the fluid remains relatively constant. There exists also the possibility that the action of the body fluid is a complex one in vivo in a way similar to the complex action after homoiotransplantation. In the case of both types of substances (those preformed and those produced through immunization), we are able to point to analogous substances existing elsewhere, namely, the preformed species-specific tissue coagulins, which play a rôle in the blood coagulation, and the secondarily, artificially produced antibodies of various kinds. It also remains further to be determined, how far the metabolic products of foreign cells exert a direct influence upon each other and how much of this effect is dependent upon the interaction between cells and foreign body fluids.

In addition to the effect of toxic substances, mere lack of common food-stuffs can also retard tumor growth, as the retarded growth of transplanted tumors in pregnancy and the feeding experiments of Moreschi, Peyton Rous, Beebe, Sweet, Corson White, and Saxon, Robertson and Burnett have shown. Other substances apparently stimulate tumor growth (Robertson and Burnett). Whether an immunity caused through the lack of specific substances—in contradistinction to the common food and growth stuffs of cells—whether, in other words, an athreptic immunity, as Ehrlich called it, exists, however, is very doubtful. Such an athreptic immunity certainly would not explain the phenomena referred to above, as especially the experiments of Uhlenhuth, Haendel and Steffenhagen, Tyzzer and Levin have shown.

In the retarded cancer growth in pregnancy especially we do not have to deal with a scarcity in specific growth substances, particularly in hormones, as Ehrlich supposed, but with a shortage in the ordinary substances required for the building up of cells. On the contrary, it seems to us very probable that certain hormones which circulate during pregnancy may be of advantage to tumor growth, and that these two antagonistic factors—deficiency in ordinary building material and presence of special hormones—may preponderate unequally in different cases and thus the difference in the effects on tumor growth which certain investigators found in pregnancy may be explained.

In connection with the studies in metabolism to which we have just referred, we may look forward to interesting results through further analysis of the chemical constitution of tumor tissues.

I am, however, inclined to regard the differences so far found between normal and tumor cells in a similar light, as differences observed in the case of mitotic division in normal and tumor cells, both probably being the result and not the cause of the changes in the growth energy characteristic of tumor cells.

Having arrived at the end of our survey, we must confess that much remains still to be done before these investigations can in any way be considered near completion. On the other hand, I believe that I have indicated that there are yet other ways open for further attack upon the problems of cancer and tissue growth, and I hope also that I have been able to convey the impression that the work of so many investigators in this field has not been in vain, and that not only this special branch of science has been built up, but that also biology

and pathology in general have been stimulated and enriched as the result of their labors.

LEO LOEB
DEPARTMENT OF COMPARATIVE PATHOLOGY,
WASHINGTON UNIVERSITY

THE UNITED STATES FISHERIES BIOLOGICAL STATION AT BEAUFORT, N. C., DURING 1914 AND 1915

THE laboratory of the U. S. Fisheries Biological Station at Beaufort, N. C., has been open for investigators each summer for the past seventeen years. Below is given a brief summary of the various activities of the station during the years 1914 and 1915.

The many improvements and repairs effected during the past two years have contributed materially to the appearance of the small island on which the station is located, and to the working efficiency of the laboratory. The grounds were graded and covered with a coat of black top soil in which grass was planted and grown with success. An additional breakwater was built, the terrapin pounds were enlarged, and a fish pool and tide pool were constructed. The cedar post foundation of the main building was replaced by brick piers, the old coal house was rebuilt into a boat house, connected with marine boat ways, and a new coal bin connected with the power house was constructed. About 338 square feet of concrete walks were laid. Porches were constructed across the ends and south side of the dormitory rooms. These added much to the appearance of the building and the comfortableness of the bed chambers. A library room and a small laboratory have been provided on the lower floor of the main building. The power house has been equipped with a salt-water pump of such ample dimensions that the 10,000-gallon salt-water tank can be filled in about one seventh of the time previously required, with a consequent saving in labor and fuel. A new projection and micro-photographic apparatus was added to the laboratory equipment.

Under the direction of the librarian of the central office of the Bureau the library has been systematically arranged and catalogued. The number of volumes has been increased by both purchase and voluntary contributions of publications on biological subjects from various authors and institutions.

Most of the investigators who were employed during the past two years had been with the laboratory before, and continued lines of work begun previously. Professor H. V. Wilson, of the University of North Carolina, was at the laboratory for a short time during both summers. He continued the study and identification of the Albatross-Philippine sponge collection. Nearly all the forms studied differ in more or less important respects from described forms and most of them will be published as new species or varieties.

Dr. S. O. Mast, of Johns Hopkins University, was with the laboratory during the summer of 1914 and continued his studies of the previous season on the changes in shades, color and patterns in fishes, with especial reference to the flounders, *Paralichthys* and *Ancylopsetta*. He also made some observations on the behavior of *Fundulus majalis* in tide pools.

Dr. Mast was unable to demonstrate that adaptation to background in the above-named flounders has any biological value. Experiments, however, indicate that there is in flounders a tendency to select bottoms which harmonize with their skin in color as well as in shade. It was also shown that flounders do not compare their skin with the bottom in the process of adaptation, but that this is regulated solely by the effect of light received by the eyes from above and by its reflection from the bottom. The results of Dr. Mast's work also indicate that the fusion rate of images on the retina for flounders and for man is the same.

With reference to the behavior of *Fundulus majalis*, Dr. Mast's observations indicate that this fish has a sense of direction probably somewhat similar to certain birds. It was noticed many times that when a school of these fish was left in a tide pool as the water fell they left the pool and crossed a sand bar, continuing their flops toward the sea until water was reached, and seldom making the mistake of coming out on the wrong side of the pool.

Dr. Albert Kuntz, of the St. Louis University School of Medicine, during the summer of 1914 continued for the third season his investigation of the breeding habits, embryology and larval development of the fishes of the vicinity. His observations for the season were based exclusively on living material on the eggs and larvæ of five species of teleosts, viz.; *Cyprinodon variegatus, Lucania parva, Kirtlandia vagrans, Gobiosoma bosci* and *Ctenogobius stigmaticus*. The eggs of each species were fertilized and hatched in the laboratory.

Drawings illustrating different stages of development were prepared by Mrs. Decker, an artist, employed for the station. The chief purpose of this work was to give descriptions, along with the illustrations, that would afford ready means of identifying the eggs and larvæ of the species studied.

Mr. H. F. Taylor, then of the Tarboro High School, Tarboro, N. C., now an assistant in the Bureau of Fisheries, devoted the season of 1914 almost exclusively to the study of the scales of the menhaden (*Brevoortia tyrannus*). The results of Mr. Taylor's work indicate that this fish lives to be five or six, or rarely seven years old, and that it spawns about the fifth year. The year groups have approximately the following lengths; first year, 9 cm.; second year, 15 cm.; third year, 18.5 cm.; fourth year, 20 cm.; fifth year, 22 cm.; sixth year, 24 cm.; seventh year, 26.5 cm. The indications also are that the spawning time is very protracted or that there is a secondary spawning time in addition to the regular November spawning.

Prof. W. P. Hay, of the Washington, D. C., high schools, continued his experiments of previous seasons in diamond-back terrapin culture, the study of the life history of the blue crab, and the report on the decapod crustaceans of the Beaufort region.

The present series of experiments in diamond-back terrapin culture were first undertaken at this station in 1909. Since that time nearly 6,000 young terrapins have been hatched in the ponds at the laboratory. The brood of 1914 numbered 1,631 on November 10, an increase of 207 over the total number of the 1913 brood. The 1915 brood numbered 2,035 on the same date of the present year. Nearly 2,000 young terrapins, representing the various broods, are retained at the station for experimental purposes. A marked improvement in the size and vigor of the broods from year to year is apparent, indicating that the adult breeding stock is adapting itself more and more to life in captivity. The various broods are divided into two or more lots each of which is handled differently in order to determine the best treatment of the animal in captivity. Some of the individuals of the broods of 1909, 1910 and 1911 have reached a marketable size, *e. g.*, six inches or more in length, measuring the lower shell. The broods of 1909 and 1910 both produced eggs for the first time during the summer of 1915. The young hatched from these eggs, while they are vigorous and healthy, are notably smaller than the average size of those hatched from eggs produced by the adult breeding stock. During the winter of 1914 and 1915, nearly the entire brood of 1914 and 83 of the brood of 1911 were kept in the hot house. Contrary to the custom of previous winters, some of them were fed on fresh instead of salted food in order to determine the advantage or disadvantage of either. Those fed on fresh food had attained greater growth by spring when all were placed outside in concrete inclosures, after which, as usual, all were fed on fresh fish. When measured in September, 1915, the difference in size between the two lots was not so apparent. The brood of 1915 is being kept in the hot house and the experiment of the previous winter with reference to fresh and salted food is being continued.

On the study of the life history and behavior of the blue crab, Mr. Hay reports that the data collected indicate that the intervals between moults and the amount of growth at moulting time is quite variable and is determined by the amount of the food supply. The crab probably attains sexual maturity at three years of age, when also it has usually attained its maximum normal growth and then ceases to moult.

The report on the decapod crustaceans of the Beaufort region, which was originally be-

gun by Dr. C. A. Shore and later continued by Mr. Hay, has been nearly completed and will probably go to press at an early date.

Dr. H. S. Davis, of the University of Florida, devoted the two seasons to the continuation and completion of investigations on the Myxosporidian parasites of fishes occurring in the Beaufort region. The parasites are common in nearly all the fishes of the region. There is in fact scarcely a species which is not infested by one or more species. The results of these investigations have been embodied in a paper on the Myxosporidia of the Beaufort Region, which is nearly ready for publication.

Dr. James J. Wolfe of Trinity College, Durham, N. C., during both seasons under consideration continued his experiments on the brown alga, *Padina,* and the examination of the *Diatomaceæ* of the Beaufort region. It is expected that a paper covering the results of the experiments on *Padina* will soon be published. Dr. Wolfe is preparing a rather extensive and profusely illustrated report on the diatoms. Many microphotographic plates, which were retouched by the artist, have already been prepared.

Dr. L. F. Shackell, of the St. Louis University School of Medicine, continued his experiments begun in 1912 on the preservation of wood against marine borers. During the past two seasons these studies were carried on in collaboration with the staff of the U. S. Forest Products Laboratory, Madison, Wisconsin. A special study was made of the toxicity of coal-tar creosote and its fractions for certain borers. During the season of 1914 the common ship worm, *Xylotrya,* was used in the experiments, and during 1915 the common wood-boring crustacean, *Limnoria,* was used in the same series of experiments. The results were about the same for each. The results of the 1914 experiments have already been recorded in the *Proceedings* of the American Wood Preservers' Association for 1915. During the summer of 1915 specimens of wood treated with various coal-tar creosote preparations were exposed to the water of the harbor. These specimens are, of course, to be carefully examined in order to determine the effectiveness of the different treatments.

Dr. William L. Dolley, Jr., of Randolph-Macon College, began in 1914 an investigation of the copepods of the Beaufort region. Collections were made and forms occurring most frequently were identified. Unfortunately Dr. Dolley's work was greatly interrupted by sickness. Dr. Dolley was unable to return for the continuation of this work during the summer of 1915.

Dr. C. H. Edmondson, now of the University of Oregon, formerly of the University of Iowa, continued during the summer of 1915 the collection and identification of the foraminifera of the Beaufort region. During the past season over two hundred species were collected and provisionally identified and taken to the university for further study.

Mr. Radcliffe, of the Bureau of Fisheries, Washington, D. C., was at the laboratory during the summer of 1914. He continued the work of the report on the sharks and skates of the Beaufort region and had charge of the work done by the *Fish Hawk* during its stay in the vicinity.

Professor O. W. Hyman, of the University of Tennessee, during the summer of 1915 made some investigations regarding the artificial propagation of the common clam, *Venus mercenaria.* It was, however, determined that the spawning season was nearly over, and that this work should be undertaken earlier in the season, *e. g.,* probably as early as April. Mr. Hyman also worked on the early larval forms of certain decapod crustaceans of the Beaufort region. Of ten forms the first zœas were secured, in six of them the second zœas and in three the third zœas were secured. The method of procedure in each case was to get a ripe female with eggs and keep her in the laboratory until the eggs hatched. Each stage of the zœa was described and drawn with camera lucida.

Mr. Arthur Jacot, of Cornell University, spent the season of 1915 at the laboratory making a study of the mullets of the vicinity with especial reference to their spawning habits and the young, or *Querimanna* stage. It had been noticed by the director that young of one inch and less in length could be obtained throughout the year. It had also been reliably reported by

fishermen that mullets with roe are occasionally taken during the spring of the year. These mullets were identified by the fishermen as the common jumping mullet, *Mugil cephalus,* which species is pretty definitely known to spawn in this vicinity during the fall of the year.

Mr. Jacot found that all of the young of one inch and less in length taken during the winter are *Mugil cephalus,* and all of those taken during the summer are *Mugil curema.* This is very interesting in view of the fact that the adults of the latter species are rare in the vicinity, while the young are quite abundant. The exact spawning grounds of the mullets is not known, neither has it been possible to obtain young much less than three fourths of an inch in length. For these reasons the probability of an early migration of the young presents itself, and the knowledge now gained may finally aid in locating their spawning grounds.

Mr. H. S. Willis, a medical student of the Johns Hopkins University, who was with the laboratory in 1915 was detailed as naturalist aboard the steamer *Fish Hawk.* Besides this he made some camera lucida drawings for Dr. Mast of scales of flounders that had been held on variously colored backgrounds for a long period of time. He also rendered considerable assistance to the director in the preparation of a report on the teleosts of the Beaufort region.

Mrs. Effie B. Decker, of Washington, D. C., an artist, was with the laboratory during both seasons. She made illustrations and retouched photographic plates for the various lines of work conducted by the station.

Besides the above-named individuals employed by the Bureau the following persons visited the station as independent workers: Mr. W. C. George, of the University of North Carolina, spent a portion of June and July, 1914, at the laboratory investigating the Ascidians. He followed out the egg development of *Stylea plicata,* and studied some of the phenomena of degeneration and regeneration of *Perophera.*

Dr. G. L. Kite, of the Henry Phipps Institute, Philadelphia, spent about six weeks at the laboratory during June and July, 1914, devoting his time to the study of certain phases of the embryology of the white sea urchin *Toxopneustes* and that of the worm *Thalassema* which inhabits the dead tests of the sand dollar. Professor Ulric Dahlgren, of Princeton University, spent several weeks at the station during July and August, 1914, for the purpose of collecting the young of *Astroscopus y-græcum,* of the electric organs of which he is making an exhaustive study. His efforts at that time were, however, unsuccessful, as no young were obtained. Mr. August Webber, of New York, N. Y., spent about two weeks at the laboratory during August, 1915, collecting birds for the Brooklyn Institute and bird stomachs for the U. S. Biological Survey.

The director devoted such time as could be spared from other duties mainly to the study of the breeding habits of fishes. During April, 1913, Mr. Radcliffe examined a few specimens of flounders, identified as *Paralichthys lethostigmus,* containing roe. During 1914 and 1915 the spawning habits of the flounders were further investigated with the view of taking up the artificial propagation of these fishes if possible. No flounders containing roe were taken during the spring, but during the fall of each of these years several specimens have been secured with well-developed roe. In every case these were large females, which are comparatively rare. No male with developed roe has yet been observed.

The spawning habits of the weak fish *Cynoscion regalis* and the pig fish *Orthopristis chrysopterus* were also investigated. The data collected indicate that these species run out to sea to deliver their spawn. Data were also collected on the spawning habits of *Bairdiella chrysura,* and a number of minnows. Several experiments were performed in the laboratory with the viviparous species *Gambusia affinis* and with *Cyprinodon variegatus.* Data collected indicate that several of the minnows have a protracted spawning season, producing eggs throughout the greater part of the summer.

It is believed that the following species were taken for the first time in this vicinity during the past two years: (*a*) *Urophycis floridanus,* (*b*) *Menidia beryllina,* (*c*) *Sphyræna barracuda,* (*d*) *Fundulus ocellaris,* (*e*) *Fundulus*

luciæ. The last-named species appears to have been taken only twice previously, once on the New Jersey coast and later on the lower Potomac. This species is fairly common in the Mullet Pond and very abundant in the very shallow and muddy ponds on the marshes to the westward of the entrance of the canal on Newport River.

On July 16, 1914, a first-class can buoy, painted with red and white spiral stripes, was planted on the black-fish grounds off Beaufort as an aid to fishermen desiring the use of the bank. The buoy is 21⅓ miles S. by W. ⅞ W. of the whistle buoy on Beaufort Bar; 23½ miles SW. ¼ W. of Lookout Light; and 26 miles SE. by E. ½ E. of New River Inlet. These grounds have been pretty carefully surveyed and charted by the *Fish Hawk*. This bank is about six miles in length and over one half mile wide at the broadest point. It has been possible to obtain an abundance of fish there at all times when the bank was visited by the *Fish Hawk*. So far but little use has been made of this source of food supply, but it is hoped that in the near future fishermen will avail themselves of the opportunity there presented.

SAMUEL F. HILDEBRAND

ALVIN DAVISON

DR. ALVIN DAVISON, professor of biology at Lafayette College, Easton, Pa., died on the thirty-first of July. Dr. Davison was best known, perhaps, as the author of seven widely-used text-books on biological subjects—on zoology, physiology, anatomy and hygiene. He was also well known as the original advocate of the movement to dispense with the public drinking cup, as a frequent contributor to scientific magazines, as an able and entertaining lecturer and as a competent expert witness in both civil and criminal trials.

Although an author and scientific man of high standing, Dr. Davison will longest be remembered as a teacher. In September, 1894, he founded the department of biology at Lafayette, and since that time this department has turned out large numbers of biological workers who quickly assumed positions of leadership in the biological field. A number of well-known teachers of biology in the colleges of the eastern United States, and numerous entomologists, bacteriologists and foresters connected with the state and federal governments received their training under Dr. Davison.

A noted health worker recently wrote to the widow of Dr. Davison:

> I know he has meant a great deal to many students, but I doubt if the work and life of any one with whom he came into contact was more profoundly influenced by him than was my own. Any good I may have ever accomplished in the social and health field will be in large measure due to the sense of direction imparted to me by your husband while I was in his classes.

A professor of biology in one of our eastern colleges wrote:

> But for your husband my college course would have been largely wasted; but for him I would not now be engaged in the useful work I am doing.

Scores of similar communications attest the great influence which this unusual teacher exerted upon his students.

By inclination and training Dr. Davison was unusually fitted to pursue research work in science. After graduating from college, he took up postgraduate work at Princeton University, and later on studied in Freiburg under Weissman and Weidersheim. Although very fond of research work, and, as his books and magazine articles reveal, although he did no little amount of it, he felt that he could do a greater work for science by opening the eyes of others and starting them on the way he was traveling. He with Ruskin deplored the fact that "hundreds of people can talk where one can think and thousands can think where one can see." His greatest work was teaching his pupils "to see."

At the time of his death Dr. Davison was forty-eight years of age. Up to within a few days of his death he was busily engaged in working upon the eighth volume of his series of biology text-books.

H. D. BAILEY

MUHLENBERG COLLEGE

PRESENTATION OF A PORTRAIT OF J. PETER LESLEY

The University Day program at the University of Pennsylvania, on February 22, included the presentation of a portrait of the late J. Peter Lesley, who was professor of geology and mining from 1872 to 1890, and subsequently professor emeritus of geology and mining until his death in 1903. The portrait is the gift of Joseph G. Rosengarten, and was painted by Lesley's daughter, Mrs. Margaret Lesley Bush-Brown. The presentation address was made by Professor Amos P. Brown, who said:

Mr. Provost: I have the honor to present to the university, on behalf of the donor, this oil portrait of J. P. Lesley, late professor of geology and mining in the University of Pennsylvania; and it seems as appropriate as it is fortunate that the artist could be his own daughter, Mrs. Margaret Lesley Bush-Brown. Peter Lesley, topographical geologist and expert, characterized as "one of the most distinguished and lovable men of science in the United States," was born in Philadelphia on the 17th of September, 1819; he died at Milton, Massachusetts, on the 1st of June, 1903. Throughout a long life he was always, primarily, a student of geology. He entered the University of Pennsylvania at the age of fifteen, and after winning high honors, including his Phi Beta Kappa, he was graduated a Bachelor of Arts with the class of 1838 C. In the same year he began his geological career as aid, under Henry Darwin Rogers, on the recently initiated First Geological Survey of Pennsylvania. It was then that he commenced those studies in Appalachian structure in which he afterwards became so preeminent a master, and which made him rank as the foremost geological expert in his state. This position not only brought him much employment in his profession, but also brought with it many honors; he was selected as one of the original members of the National Academy of Sciences at Washington, in 1863, given the degree of Doctor of Laws by Trinity College, Dublin, in 1878, and he received a gold medal from Paris "for original investigations" in 1889. When the university was removed from the center of the city to West Philadelphia in 1872, Dr. Lesley was appointed professor of geology and mining, and dean of the science department; and when, three years later, the Towne Scientific School was opened, he was made its first dean. But the crowning honor of his career came with his appointment as director of the Second Geological Survey of Pennsylvania in 1874, a position for which he had no competitor. To quote Sir Archibald Geikie, himself the head of a geological survey: "The one hundred and twenty volumes of this survey issued under his direction, and the Summary Final Report, more than half of it from his own pen, will form the noblest monument to the genius of J. P. Lesley."

In accepting the portrait, Provost Smith said:

J. Peter Lesley was indeed preeminent as a geologist. His discoveries live because of their fundamental character. The university in which he received the academic training, and to which he gave the best years of his life as a teacher, deeply appreciated his successes and rejoiced in the universal recognition accorded him as a scientist. The trustees of the university are glad to have this portrait and, through me, return their sincere thanks to the thoughtful and generous donors.

SCIENTIFIC NOTES AND NEWS

Sir F. W. Dyson, the English astronomer royal, and Dr. C. S. Sherrington, professor of physiology at Oxford, have been elected corresponding members of the Petrograd Imperial Academy of Sciences.

The Paris Academy of Medicine has elected as foreign correspondents Professor Ladame, of Geneva, and Sir Dyce Duckworth, of London.

At the Royal College of Physicians of London, Sir Thomas Barlow is to be the Harveian orator for the present year, Dr. H. W. G. Mackenzie the Bradshaw lecturer, and Dr. W. J. Howarth the Milroy lecturer for 1917.

Dr. Ira Remsen, of Johns Hopkins University, addressed the Chemical Club of Princeton University, on February 18, on "Reminiscences of Liebig and Wohler."

The Vanuxem lectures at Princeton University are being given by Dr. Thomas Hunt Morgan, professor of experimental zoology in Columbia University, on February 24, March 1, 8 and 15. The subject is "A Critique of the Theory of Evolution." Professor Morgan has

been invited to give in the spring the Hitchcock lectures at the University of California.

DR. E. NEWTON HARVEY, assistant professor of physiology at Princeton University, will leave for Japan about March 18 to study the production of light by luminous animals. The trip is under the auspices of the department of marine biology of the Carnegie Institution of Washington.

DR. C. J. MARSHALL, professor of veterinary medicine in the veterinary school of the University of Pennsylvania, will sail from New York on the steamer *Rotterdam* on March 7, visiting England and France to make observations in the hope that the information obtained will be of service to America.

ANDREW H. PATTERSON, head of the department of physics at the University of North Carolina, is on leave of absence from that institution and is with a corporation in New York City.

To further the work begun by Dr. Samuel J. Barnett, of the department of physics of the Ohio State University, as to the cause of the earth's magnetism, the board of trustees of the university has appropriated $300.

THE survey of the fish of Oneida Lake begun last summer by the New York State College of Forestry, at Syracuse, will be continued this summer. This work, under the supervision of Dr. C. C. Adams, was carried on with the cooperation of Professor T. L. Hankinson and Frank C. Baker. Beginning in June, the work will be continued by Messrs. Adams and Hankinson. Last summer the western half of the lake was covered and this season the remainder of the lake will be surveyed. Mr. Frank C. Baker's report on the relation of molluscs to Oneida Lake fish is completed and will soon be published by the college.

THE board of health will celebrate the semicentennial of its sanitary control of New York City and adjacent counties by a commemoration dinner to be given March 9. Among the speakers expected are the mayor of New York; the State Commissioner of Health; Surgeon-General William C. Gorgas, U. S. Army; Dr. Walter B. James; Mr. Henry Bruere, and Dr. Stephen Smith.

DR. MATTHIAS NICOLL, JR., has been appointed director of the division of public health education in the New York state department of health, and in addition will have supervision of epidemiologic investigations in the southern and eastern parts of the state. He succeeds Dr. C.-E. A. Winslow called to the Anna M. R. Lauder professorship in public health at Yale University.

A LECTURE on the history of science was given by Professor George Sarton, formerly of the University of Ghent, and editor of *Isis*, in the Doremus Lecture Theater, on February 24, at the College of the City of New York.

ON February 8, Professor George H. Shull, of Princeton University, addressed the Graduate Club of Rutgers College on "Practical Application of the 'Pure-Line' Idea of Johannsen."

ON the evening of February 8, 1916, Dr. Benjamin L. Miller, professor of geology in Lehigh University, lectured before the Harrisburg Natural History Society on his recent travels in South America.

DR. HENRY L. ELSNER, professor of medicine in Syracuse University College of Medicine, died suddenly of heart failure on February 17. Dr. Elsner was a graduate of the College of Physicians and Surgeons, Columbia University, and had achieved eminence both through practise and his critical contributions to scientific medicine. A work on "Prognosis," which has received high commendation from critics of repute, is just passing through the press.

MR. GEORGE STRICKLAND CRISWICK, assistant in the Royal Observatory, Greenwich, from 1855 to 1896, died on January 26.

DR. H. KLAATSCH, associate professor of anthropology at Breslau, died on January 7, at the age of fifty-two years.

EDMOND HECKEL, professor of materia medica at Marseilles, has died, aged seventy-three years.

THE Woman's Medical College of Pennsylvania has established a fellowship amounting

to $1,000 to be awarded annually to any medical woman of special ability who, following the undergraduate course, has completed at least one year of hospital service, including work in maternity wards, and one year of further practise. The amount is to cover twelve months of special work as fellow in obstetrics, with the condition that the holder of the fellowship shall thereafter continue the practise of obstetrics.

The Woman's Medical Association of New York City offers the Mary Putnam Jacobi fellowship of $800, available for post-graduate study. It is open to any woman physician for work in any of the medical sciences. The fellowship will not be awarded by competitive examination, but upon proof of ability and promise of success in the chosen line of work. Applications for the year 1916–17 must be in the hands of the Committee on Award by April 1, 1916, and should be addressed to Dr. Annie S. Daniel, 26 Gramercy Park, New York City.

According to the *Journal* of the American Medical Association the Rockefeller Institute for Medical Research has let contracts for the buildings for its work in comparative pathology near Princeton, N. J., as follows: laboratories at a cost of $90,615; power house and tunnels, $102,556; operating building, $27,838. The work is to be finished by September 1.

The Colorado School of Mines announces that the U. S. Bureau of Mines will move its laboratory from Denver to Golden early in June. The two institutions will cooperate in investigation work. R. B. Moore and ten assistants form the bureau staff.

The United Engineering Society of New York has issued the annual report of the Library Board for 1915. The revenue was $17,445, and expenditure $16,380. There were 12,820 visitors.

In a report of the fire which destroyed the chemical laboratory of Cornell University the *Alumni News* states that it was impossible to save a great amount of material on which no monetary value can be placed. Several members of the staff lost records and data, the work of years. Notes of experiments and researches, manuscripts and personal belongings were destroyed. Professor Dennis saved most of the material in his office but lost his notes of class-room work. Professor Chamot lost his most treasured records. Professor Bancroft's working library was destroyed, together with the records and files of the *Journal of Physical Chemistry*.

The museum of the Royal College of Surgeons of England has been closed since June last, the motive being the desire to safeguard the collection from destruction during air raids. All spirit preparations and some of the more valuable of the others are now stowed in the basement, but those who desire to study any particular specimen will be permitted to do so. The conservator, Dr. Keith, is still in attendance, and anatomical and other scientific work is carried on in the workrooms of the college.

An appeal, signed by 246 German and Austrian scientific men, has been made to the public not to cease to subscribe to scientific periodicals. Such periodicals, the memorialists state, are indispensable to scientific progress.

The New England Association of Chemistry Teachers held its fifty-fifth regular meeting on February 12, at Harvard University. The program included remarks by Professor Theodore W. Richards; an address on "Radium and its Contribution to Chemistry," by Mr. Gerald L. Wendt, Austin teaching fellow, Harvard University, and an address on "Transformations by High Pressure," by Professor P. W. Bridgman.

The eighth annual meeting of the National Committee for Mental Hygiene, held on February 2 in New York, was attended by a large group of distinguished alienists, social workers and philanthropists. Mr. Otto T. Bannard, the treasurer, announced that the Rockefeller Foundation had donated to the National Committee $22,800 for carrying on surveys of the care of the insane in sixteen states during the present year, supplementing gifts of Mrs. William K. Vanderbilt, Mrs. A. A. Anderson and Mr. Henry Phipps. The following offi-

cers were elected: *President,* Dr. Lewellys F. Barker; *Vice-presidents,* Dr. Charles W. Eliot and Dr. William H. Welch; *Treasurer,* Otto T. Bannard; *Medical Director,* Dr. Thomas W. Salmon; *Secretary,* Clifford W. Beers; *Executive Committee,* Dr. August Hoch, chairman, Dr. George Blumer, Professor Stephen P. Duggan, Dr. William Mabon, Dr. William L. Russell and Dr. Lewellys F. Barker; *Finance Committee,* Professor Russell H. Chittenden, chairman, Otto T. Bannard, Dr. Henry B. Favill and William J. Hoggson; *Committee on Mental Deficiency,* Dr. Walter B. Fernald, chairman, Dr. L. Pierce Clark, Professor E. R. Johnstone, Dr. Charles S. Little and Dr. Albert C. Rogers.

THE twenty-seventh session of the biological laboratory of the Brooklyn Institute of Arts and Sciences, located at Cold Spring Harbor, will be held in the summer of 1916. Special facilities are offered to investigators and two scholarships of $100 each are available for such. Courses are given in field zoology by Drs. Walter and Kornhauser; in bird study by Mrs. Walter and Dr. Ehinger; in comparative anatomy by Dr. Pratt and Mr. Hine; in beginning investigation, especially in animal bionomics and genetics by Drs. Davenport, Pratt and Walter; in cryptogamic botany by Dr. H. H. York; in systematic and field botany by Dr. Harshberger and Mr. Miller and in training for eugenical field work by Dr. Davenport and Mr. Laughlin. Class work begins on July 5; tuition is $30. The new announcement may be obtained from, and application for scholarships made to, Dr. C. B. Davenport, Cold Spring Harbor, Long Island, N. Y.

THE *Journal* of the American Medical Association states that the Amsterdam Genootschap ter Bevordering van Natuur-, Genees- en Heelkunde founded in 1790, held recently its one hundred and twenty-fifth annual meeting when Dr. C. C. Delprat reviewed its history and achievements. The address is published in the opening number of the *Nederlandsch Tijdschrift voor Geneeskunde* for 1916, which begins its sixtieth year. It is accompanied by a dozen engravings showing the amphitheater for teaching of anatomy, 1690; lecture room, 1760; hospital, 1763, and a number of early officers of the society. The gala meeting was presided over by Professor G. van Rijnberk, who is also editor of the *Tijdschrift.* The society awards the Swammerdam medal every tenth year. The four recipients have been the Germans, Siebold, Haeckel and Gegenbaur, and the Netherlands scientist, Hugo de Vries. The Tilanus medal has been awarded every five years since the death of this eminent surgeon. It is given for the best work on some surgical or medical subject, and has been awarded to Zwaardemaker, C. de Mooy, L. Bolk and J. Boeke, all of the Netherlands. The society also distributes some stipends to medical students for study abroad, and has officially contributed to a number of endowment funds in honor of various foreign scientific men.

UNIVERSITY AND EDUCATIONAL NEWS

THE University of Buffalo has received actual and provisional endowment for the new department of arts and sciences amounting to $750,000. $100,000 of this sum to be given outright by Mrs. Seymour H. Knox, who, with her children, proposes to increase this eventually to a total of $500,000. $250,000 is given by General Edmund Hayes for the first building upon the university site, provided $1,000,000 be raised for like purposes before June, 1919.

PRESIDENT GOODNOW at the commencement exercises of the Johns Hopkins University, on February 22, announced that the Consolidated Gas Company of New York, the American Gas Company of Philadelphia and the Consolidated Gas Company of Baltimore had interested themselves in the establishment of a laboratory at the university for research work as to the possibilities of coal tar products. The purpose is to develop the aniline dye industry and other important branches in the coal tar field.

THE Graduate School of Agriculture will be held at the Massachusetts Agricultural College July 3–28, 1916. This school is under the auspices of the Association of American Agricultural Colleges and Experiment Stations. Dr.

A. C. True, of Washington, D. C., is the dean of the school, and the assistant dean is Professor Charles E. Marshall, director of the graduate school and professor of microbiology at the Massachusetts College. The school is open to all college graduates. Its purpose is for the study of the recent development in the natural, social and economic sciences as applied to agriculture, as well as in the technical branches of the so-called practical agriculture. Courses are offered in (1) growth, (2) production, (3) rural organization, (4) agricultural education, (5) distribution-marketing, (6) land problems, (7) adjunct course in physico-chemico-physiological elements, (8) special lectures and conferences.

From May 1 to November 30, fourth-year medical students at Toronto will be given a summer course to qualify for their degree, and there will be no fifth-year course next year at the university. The summer session will last twenty-six weeks. There will be sixty men who will attend the summer session, and when they graduate they will be in a position to accept positions with the various hospital units. It is understood that Queen's University, Kingston, will take a similar step.

The trustees of Northwestern University at their last meeting filled the vacancy in the deanship of the dental school, which occurred through the death of Dr. Greene Vardiman Black on August 31 of last year, by the election of Thomas Lewis Gilmer, M.D., D.D.S., Sc.D.

At Smith College, Dr. Joel E. Goldthwaite has been appointed professor of hygiene and physical education, and Miss Pauline Sperry, assistant professor of mathematics. Miss Harriet R. Cobb has been promoted to be professor of mathematics; Dr. Mary M. Hopkins to be associate professor of astronomy, and Mrs. Anna B. Newell to be assistant professor of zoology.

At Harvard University Dr. Dunham Jackson has been promoted to an assistant professorship of mathematics.

The chair of botany in the Alabama Polytechnic Institute and Agricultural Experiment Station, vacant by the resignation of Dr. J. S. Caldwell to take up the position of "By-Products Specialist" for the Washington Agricultural Experiment Station, has been filled by the appointment of W. J. Robbins, Ph.D. (Cornell), instructor in botany in the New York State College of Agriculture.

DISCUSSION AND CORRESPONDENCE

THE FUNDAMENTAL EQUATION OF MECHANICS

Mr. Kent's recent letter on the "Teaching of Elementary Dynamics,"[1] with much of which I heartily agree, contains one serious error which I think should not pass unnoticed. As this error seems to me a not unnatural result of one feature of his favorite method of beginning the study of mechanics, I should like to take this opportunity to summarize, in a brief review, the three methods of beginning mechanics which have been advocated respectively by Mr. Kent, Professor Hoskins and myself.[2] To do this, I propose first to state briefly certain *dynamical principles on which we all agree;* I shall then endeavor to show that precisely these non-disputed facts *are all that the student needs to know in order to solve dynamical problems, provided he follows my method.* It is only when he endeavors to follow one of the other methods that he is led into controversial territory. If undisputed facts are sufficient for the solution of problems, why burden the student's mind (except as a matter of historical interest) with needless disputations?

I. The following statements will, I believe, be accepted as true by all of us, though the emphasis placed on the various items would doubtless vary.

1. A *force* is a familiar notion which may be thought of as a push or a pull. Any given force may be *identified,* that is, preserved for

[1] Science, December 24, 1915.

[2] See articles in Science by L. M. Hoskins, December 4, 1914, April 23, May 7, August 27 and September 10, 1915; by E. V. Huntington, February 5 and July 30, 1915; and by William Kent, March 19 and December 24, 1915.

reference, by noting the distance it compresses an (idealized) standard spring.

2. To *measure* a force, we require a *unit* force, and a *scale* of multiples and submultiples of that unit. Such a scale can be readily constructed by simply opposing one or more springs, in various combinations, against the standard, or unit, spring. (This process of calibrating a spring balance does not involve any assumption in regard to Hooke's Law; it requires merely that the elastic properties of the spring, whatever they may be, do not, in the ideal case, vary with the time.)

3. A *material body,* or lump of matter, is a familiar notion, in the sense that if any material is added to or taken away from the body, it ceases to be the same body. (In this discussion, "body" is used in the sense of "particle," that is, a body which may be supposed, for the purpose in hand, to be concentrated at a single point.)

4. A *motion* of a body, with respect to a given frame of reference, is also a familiar idea. The scientific concepts of *velocity* and *acceleration* serve merely to make quantitatively precise our qualitative notions of "faster" and "slower."

5. The *effect of a force* when applied to a body free to move, is to *change the velocity* of the body. As a matter of common observation, the force required to produce a given change of velocity in a given time is larger for some bodies than for others.

6. *If a given body is acted on, at two different times, by two forces, F and F', and if a and a' are the corresponding accelerations, then*

$$F/F' = a/a';$$

that is, in the case of any given body, *the accelerations are proportional to the forces.* This statement is best regarded as a scientific hypothesis, the consequences of which have been abundantly verified by experiment.

7. In order to *predict the behavior of any given body* under the action of various forces (and this is the central problem of dynamics), it is sufficient, and necessary, to know from some (direct or indirect) experiment, what acceleration some one force would produce in that body. The acceleration, a, that would be produced by any other force can then be computed at once by the fundamental proportion.

In the special case in which the acceleration a is constant, and the body starts from rest, $v = at$ and $x = \frac{1}{2}at^2$; in the general case, v and x must be obtained from a by integration.

The foregoing items 1–7 are quite general;[3] the following, 8–11, are suggested primarily by observations on the earth's surface.

8. The observed acceleration, g, of a freely falling body, in any locality, is the same for all bodies. By the "standard locality" is meant any locality (for example, approximately 45° latitude, sea level) in which $g = g_n = 980.665$ cm./sec.^{2} $= 32.1740$ ft./sec.^{2}, this being the convention now generally adopted.[4]

9. (*a*) *The force required to support a body at rest with respect to the earth in the standard locality,* and (*b*) *the force which would give that body, if free to move* (in any locality) *the standard acceleration g_n, are the same.* This force, which is characteristic of the given body, is what I have called the *standard weight,* W_n, of the body.[5] By the fundamental proportion, if F is any other force, and a the corresponding acceleration, then $F/W_n = a/g_n$.

10. The "standard weight" of a body can always be found (in any locality) by the familiar process of "*weighing*" *the body on a beam balance.*

For example, suppose a given body balances

[3] The principle of action and reaction, the principle of the vector addition of forces and the principle of the independence of two perpendicular forces, together with the definitions of such terms as work, kinetic energy, impulse, momentum, etc., although necessary for the development of the science, may be passed over without comment, as they are not now in dispute.

[4] International Conference on Weights and Measures, Procès-Verbaux des Séances, page 172, Paris, 1901; U. S. Bureau of Standards, Circular No. 34, second edition, page 6, 1914.

[5] SCIENCE, July 30, 1915, page 161. A defect in my earlier form of the definition (*Bulletin of the Society for the Promotion of Engineering Education,* June, 1913; compare U. S. Bureau of Standards, *loc. cit.,* page 7) was called to my attention by Professor Hoskins's criticism in SCIENCE, April 23, 1915.

a "1 lb. weight" in a given locality; this means, primarily, that the force required to support the given body, in the given locality, is equal to the force required to support the "1 lb. weight" in that locality; hence, by a simple inference, the force required to support the given body in the standard locality will be equal to the force required to support the "1 lb. weight" in the standard locality; but the force required to support the "1 lb. weight" in the standard locality is guaranteed to be "1 lb."; hence the force required to support the given body in the standard locality—that is, the "standard weight" of the body—is also 1 lb.

11. Finally, *if the standard weight of a body is known, the dynamical properties of the body are wholly determined.* For example, if we wish to find the acceleration, a, produced by any force F in a body whose standard weight is W_0, we have merely to substitute the given values in the equation $F/W_0 = a/g_0$ and solve for a.

In other words, the simple principles enumerated above—principles the truth of which has not been called in question—form a complete and satisfactory foundation for the solution of elementary problems in dynamics. It should be particularly noted that no restrictions whatever are imposed on the choice of the fundamental units of force, length and time; and that the only datum that we need to know in advance concerning any body that enters a problem is a single, readily determined force, namely, the standard weight of the body.

II. Let us now turn to Professor Hoskins's method, and inquire what items one of the very best of the modern text-book writers regards it as necessary to add to these familiar principles.

In his article in Science for April 23, 1915, page 608, he says:

> The method most intelligible to the beginner is to introduce at the outset the body-constant which was called by Newton mass or quantity of matter, and to make the fundamental principle . . . the following: (*a*) A force acting upon a body otherwise free would give it, at every instant, an acceleration proportional directly to the force and inversely to the mass of the body.

His fundamental equation is therefore

$$\frac{a}{a'} = \frac{F}{F'} \cdot \frac{m'}{m},$$

which is immediately thrown, by a perfectly arbitrary restriction on the choice of units, into the final form: $F = ma$.

It will be noticed that this method of Professor Hoskins, and most other authors, involves four fundamental concepts, namely, force, length, time and mass; while my method involves only three, namely, force, length and time. My chief objection to this complication is not merely that the fourth concept, mass, is superfluous, *as a fundamental concept,* but also that this concept is, *at this stage,* exceedingly ill-defined. Nowhere in Professor Hoskins's papers can one find a clear-cut statement of what he really intends the student, at the outset, to understand by mass. If he means merely that m is a quantity proportional to F/a, and m' a quantity proportional to F'/a', which relations are consistent with his fundamental equation, of course no one could object to this use of symbols; but the compound quantity F/a, or W/g, which is properly called the *inertia* of the body, can surely not be understood "at the outset," before the elements out of which it is built up have been grasped; and this is clearly not Professor Hoskins's intention.

His several attempts to point out certain rather vague analogies between the concept of mass or inertia and certain other concepts,[6] have altogether failed to provide a satisfactory justification for his use of mass as a term the meaning of which can be presupposed at the outset, for nowhere does he really define the term, and nowhere does he squarely meet the objections which I have raised to this procedure.

A further objection to the equation $F = ma$, which I have dwelt upon at length elsewhere,[7] is in regard to the question of units. The choice of units which the use of this equation compels is needlessly complicated and quite

[6] L. M. Hoskins, Science, September 10, 1915.

[7] See especially Science, July 30, 1915, page 160.

unscientific. On this point I heartily endorse Mr. Kent's somewhat pungent criticisms, which are entirely in accord with previous expressions of my own.

III. Finally, let us examine Mr. Kent's method. Like Professor Hoskins, Mr. Kent introduces mass, or quantity of matter, at the outset, but unlike Professor Hoskins, he frankly defines what he means by this term—namely, the result of weighing on a beam balance. This same plan is followed by several of the writers who have taken part in this discussion, notably by Franklin and MacNutt.[8] There is no logical objection to this procedure; but—*cui bono?* The result of weighing a body on a beam balance gives primarily the standard weight of the body as we have seen in (10), above; if the standard weight of a body, which is simply a force, and which everybody understands, is all that is needed, why rename this familiar concept by a less familiar term, like "quantity of matter"? Further, what are the "dimensions" of "quantity of matter"?[9] Is it of the nature of a force, or, like inertia, of the nature of a force divided by an acceleration? Or is it wholly independent of force, length and time (in which case it is wholly superfluous)? Without doubt, *later in the course* any terms of this sort may be introduced at pleasure; but why confuse the *beginner* with any concepts that are not really needed? The elimination of this one term, quantity of matter, would bring Mr. Kent's method almost exactly into line with my own, except for one point.

This remaining point of difference, though slight, is, at least from the point of view of the teacher, an important one. My method begins frankly with the idea of acceleration as a fundamental concept—not an easy idea, but one which is so essential that the student does best who faces its difficulty squarely at the outset. Mr. Kent's method, on the other hand, begins with the comparatively simple special case in which the acceleration is constant, and introduces the real thing only later on, as a sort of afterthought. For a student who is never to go further than the special case, the method based on Mr. Kent's equation $V = FTg/W$ is well enough; and this is what I had in mind when I said that "the method was not without interest on the pedagogic side." But for the student who pursues the subject seriously, the plan of spending so much time on the simple special case is too apt to have only one result, namely that the development of an unerring, instinctive grasp of what acceleration really means is either long delayed or never attained. And this brings me to the question of the error in Mr. Kent's paper. On page 902 he asks the question:

> How can a body at rest on the earth's surface have an acceleration . . . radially toward the earth's center . . . if there is no change in the speed of rotation of the earth?

The old error of supposing that a particle moving with constant velocity in a curved path has no acceleration!

Now I have no doubt that if the matter were called to his attention, Mr. Kent would at once remember that a particle moving with a constant velocity in a circular path certainly does have an "acceleration radially toward the center," the value of which is v^2/r; but the point I am making is that in the rush of the moment he did *not* remember this most cardinal fact about accelerated motion; and I attribute the possibility of a man of his experience making a slip of this kind entirely to the grudging fashion in which the subject of acceleration was probably presented to him in his first course in mechanics—a precedent which my method refuses to follow.

EDWARD V. HUNTINGTON
HARVARD UNIVERSITY

[8] Franklin and MacNutt, SCIENCE, July 9 and September 24, 1915. In regard to the supposedly contrasted statements (*a*) and (*b*) on page 423 of their second article, it may be remarked that these authors have apparently overlooked the fact that each of these statements is a direct mathematical consequence of the other, as one may readily see by an inspection of their diagram on page 422.

[9] Mr. Kent is apparently quite oblivious of the value of the theory of dimensions, as he uses the same letter (*g*) quite indiscriminately to denote a length, a velocity, an acceleration, or a pure number!

POLARIZATION OF GLOBIGERINA

On examining a group of ancient microscopic slides of modern foraminifers it was found that they polarize very beautifully, showing with plane polarized light several concentric circular spectra and a very clear black cross with broad bands and a broadened central area. This appeared most perfectly with globigerina, the young forms with but a single globe showing most perfectly. In the larger forms each half enveloping globe shows the same phenomena very clearly. The spectral rings are crowded toward the edge of the sphere and the explanation is clearly that the hollow sphere is in effect a circular wedge with its thinnest part at the center and becoming thicker radially, at first gradually and at last much more rapidly.

It was found also that minute valves of a bivalve, in shape like a quahog, would do exactly the same things only the rings were pear-shaped with a projection at the beak of the shell and broader and brighter. It was clear that the very sharp black cross was due to the fact that the outer layer of the shell is fibrous and we may deduce that the similar black cross in the globigerina is due to a minute fibrous structure in the shell of the latter.

Thin plates of the inner mother of pearl layer of *Margaritifera* and *Pinna* polarize brilliantly and give the lemniscate of a negative biaxial mineral with the axis at right angles to the layers, and so the mineral in all these cases is doubtless aragonite.

The smaller species of deep sea *Globigerina* show all this most beautifully and are a convenient object to demonstrate the stationary black cross and the higher order spectra in concentric rings. The silicious forms, Diatoms, Polycistina and sponge spicules do not polarize. This is true of the marine sponges like *Aspergillum* and *Euplectella,* but the freshwater sponge *Grantia* from the ponds around Amherst polarizes very strongly.

B. K. Emerson

Amherst, Mass.

THE TEACHING OF THE HISTORY OF SCIENCE

To the Editor of Science: In his interesting and valuable paper on "The Teaching of the History of Science" published in Science, November 26, 1915, Mr. Brasch calls attention to early courses in this subject which were given at the Massachusetts Institute of Technology, referring particularly as one of these to a reading course on the history of the physical sciences laid out as a requisite for graduation in the course in physics. The date which he mentions for its institution is 1887.

In fact, however, its beginning was much earlier. The writer from the outset of his work as a teacher had recognized the surprising lack of perspective existing among college students, but chiefly on account of the great pressure upon the teaching staff which existed here as everywhere, it was not possible at the time to institute a course of oral lectures upon the subject and the best that could be done was to lay out a suitable course of required reading, which was necessarily limited to physical science. This reading course was established at a considerably earlier date than that mentioned by Mr. Brasch, and is found set forth in the Catalogue of the Institute for 1880–81 in the scheme of studies leading to a degree in physics. A required reading course upon the logic of scientific investigation is also referred to in the same scheme.

A similar course on the history of the natural sciences is referred to in the same catalogue of the Institute in the scheme of the course in natural history.

C. R. Cross

SCIENTIFIC BOOKS

British Ants, Their Life-History and Classification. By H. St. J. K. Donisthorpe. Plymouth: Wm. Brendon & Son, Ltd., 1915. Pp. xv + 373, 18 pls. and 92 text-figs.

In this attractive volume we are given for the first time an exhaustive monograph of the ant-fauna of Great Britain, the result of many years of patient labor by one who served his biological apprenticeship as an ardent student of myrmecophiles. The volume serves also as a useful manual for the study of ants in general since it contains concise chapters on the anatomy, development and behavior of ants and the methods of keeping and studying

them in artificial nests. Naturally the greater portion of the work is devoted to a detailed account of each species known to be indigenous to Britain, under several heads, beginning with the original description, the synonymy, a good modern description and the geographical range, and ending with full ethological notes and a list of the myrmecophiles that have been taken in the nests of each form. The synonymy has been compiled with great care and from many old and obscure sources, often inaccessible to the American student. The work concludes with a list of species introduced into Britain, compiled in great part from scattered records of specimens taken in the hothouses of Kew Gardens and in dwellings, lumber yards, etc., in other parts of the islands. Among these introduced ants are a few dangerous pests, notably the Argentine ant (*Iridomyrmex humilis*), which was found "in vast numbers in a house in Windsor Park, Belfast, in 1900, where it had been observed for eighteen months," and in the Botanic Gardens of Edinburgh in 1912, and *Pheidole megacephala,* which in many tropical regions completely destroys all insects in its environment, except the Coccids, and disseminates and attends these to the great injury of many kinds of cultivated plants.

One is surprised to find the indigenous ant-fauna of Great Britain so meager compared with that of continental Europe. Only 40 forms are recorded by Donisthorpe, comprising 28 species, 14 subspecies (often ranked as species) and 8 varieties, representing only about one third of the central European fauna. Switzerland, a much smaller area than Great Britain and one which has been very carefully explored by Forel, has 116 indigenous Formicidæ, comprising 63 species, 17 subspecies and 36 varieties. The British fauna not only lacks any species peculiar to itself, but is also deficient in a whole series of genera and subgenera known to occur in Central Europe (*Strongylognathus, Harpagoxenus, Temnothorax, Neomyrma, Crematogaster, Pheidole, Messor, Aphænogaster, Dolichoderus, Bothriomyrmex, Plagiolepis, Polyergus, Camponotus* and *Colobopsis*). Most surprising is the absence of any species of the great cosmopolitan genus *Camponotus* in Great Britain. The carpenter ant (*C. herculeanus*), which is common throughout the northern portions of North American and Eurasia, could hardly be expected to be absent, but Donisthorpe shows that all records of its indigenous occurrence in Great Britain are very dubious. Some of the continental genera such as *Strongylognathus, Harpagoxenus, Bothriomyrmex* and *Polyergus* are rare and parasitic and it is very doubtful whether they will ever be found in the British Isles. Nevertheless, the singular parasitic *Anergates atratulus* was not discovered there till 1912, when it was taken by Crawley and Donisthorpe in New Forest, Hants.

Donisthorpe does not consider the interesting questions suggested by the relations of the British to the continental ant faunas, especially the reasons for the depauperate condition of the former, for not only are there few species in Britain, but these are represented by comparatively few colonies and therefore individuals. Insular ant-faunas in nearly all parts of the world are small, either because many islands are of too recent geological origin to have received many species by immigration (*e. g.,* Cuba and other West Indian Islands), or because their original Mesozoic or early Tertiary faunas have been greatly depleted or entirely obliterated by glaciation. Thus Iceland is entirely destitute of ants, and the ant-faunas of Great Britain and New Zealand are undoubtedly the meager survivors of glaciation. But when we consider that both of these regions have mild, temperate climates and an abundant vegetation, we find it more difficult to understand why the small number of surviving species is not represented by a great number of individuals, especially when we remember that Australia, North Africa and North America, which are, at least in part, much more arid and may have more severe, continental winters, nevertheless, have abundant ant-faunas. A consideration of such facts seems to indicate that moist, cloudy, cool temperate climates are very unfavorable to ants and that this may account for the meager

development of individuals in Great Britain and New Zealand. Even on continents we may notice the same dearth of ants in cool, humid regions, as, *e. g.*, in the Selkirk Mountains of British Columbia as compared with the Rockies of Alberta. The former mountains, which are very humid and covered with a rich vegetation, have a much poorer ant fauna than the latter, which are drier and have a more meager flora, though sufficiently moist and warm to afford optimum conditions for ants during the summer months.

In addition to a great amount of taxonomic and purely descriptive material Donisthorpe's book contains many original observations on the behavior of ants, especially in the sections devoted to the species of *Lasius* (notably *L. fuliginosus* and *umbratus*) and the blood-red slavemaker (*Formica sanguinea*). The illustrations are excellent and abundant and, with few exceptions, have been specially prepared for the volume. Most interesting are the figures of the gynandromorphs and ergatandromorphs of *Formica rufibarbis, F. sanguinea* and *Myrmica scabrinodis* (Pl. IV. and Figs. 45 and 46) and of the mrymithogyne of *Lasius flavus* (Fig. 47).

The only matter open to criticism in the volume is, perhaps, Donisthorpe's too hasty adoption of the generic name *Donisthorpea* for *Lasius*. The genus *Lasius* was based by Fabricius in 1804 on *Formica nigra* L., the common garden ant, one of the most abundant insects of the northern hemisphere, and since that date universally known, both in technical and popular literature, as *Lasius niger*. In 1914 Morice and Durrant exhumed a paper by Jurine published in 1801, in which the name *Lasius* was assigned to a genus of bees. The authors therefore renamed the ant-genus *Donisthorpea*. It seems, however, that there is serious doubt concerning the status of Jurine's paper, so that we need not be in a hurry to make this deplorable change in our nomenclature. At any rate, it will probably be difficult to persuade the majority of living myrmecologists, including Forel, Emery and the reviewer, to substitute *Donisthorpea nigra* for *Lasius niger*, a name which for more than a century has been almost as much of a household term as *Musca domestica, Equus caballus* and *Canis familiaris*.

W. M. Wheeler

SPECIAL ARTICLES

THE IMPORTANCE OF BACTERIUM BULGARICUS GROUP IN ENSILAGE

This department has been investigating the microbial flora of different kinds of ensilage at various stages of fermentation throughout the past year. The presence of *Bacterium Bulgaricus* group was first observed from the preliminary examinations of miscellaneous samples of ensilage. Since that time several hundred bacteriological analyses have been made from different kinds of ensilage, and at all stages of fermentation. The results obtained offer sufficient evidence to indicate the importance of this *Bulgarian* group in the ripening of normal ensilage. In a review of the literature relating to microorganisms of ensilage, only one reference[1] could be found which mentions the presence of *Bacterium Bulgaricus* group. The reference in question cites ensilage, along with many other substances, only as a source from which *Bacterium Bulgaricus* has been isolated.

Plate cultures, made upon acidulated glucose agar, were used for the cultivation of this group. The acid (1 cc. of a 1 per cent. sterile acetic acid solution) was added directly to the plates and mixed with the glucose agar when the latter was poured into the plates. The cultures were incubated at 35°C. for four days. The media permitted the growth of practically only two groups of microorganisms; the "*acid group*" and *yeasts*. The colonies of the latter were always few in number, if present at all, and with a little practise could be easily differentiated from the *Bulgarian* group.

The *Bulgarian* colonies showed varying degrees of size and form. In size, the colonies appear as very minute forms scarcely visible to the naked eye, to a type as large as the average lactic acid colony, and often larger.

In form, the characteristic "woolly edge" colony was frequent, but the predominating type was very similar to the common *Bac-*

[1] "A Study of *B. Bulgaricus*," P. G. Heinemann and M. Hifferan, *Jour. Inf. Diseases*, Vol. 6, No. 3, June 12, 1909.

terium lactis acidi colony. This type was either lance-shaped or a small round dense colony with uniform edges. A zone of cloudiness encircling the colony was characteristic of this form. The colonies of this group were also often observed and isolated from plain agar plate cultures.

The fact that the colonies of these organisms are very similar in many respects to those of *Bacterium lactis acidi* is probably one reason why this group has been overlooked by other investigators.

Much difference was likewise noted in the morphological features of the different cultures isolated, as well as in the same culture. In size, the organisms vary from small oval rods to well defined rods and filaments.

Detailed studies of many kinds of ensilage were made from the time the material entered the silo and at frequent intervals until ensilage was formed. The following kinds of ensilage were examined: cane, kaffir, cane fodder, alfalfa, and several kinds of ensilage made from the mixture of alfalfa and different carbohydrate materials. In every case the *Bulgarian* organisms were present in sufficient numbers to be very influential in silage fermentation.

TABLE I

Action of Bulgarian Cultures in Plain and Peptone Milk

(Temperature Incubation 35° C.)

(Figures give No. c.c. of N/20 NaOH to neutralize 5 c.c. milk.)

Cultures	After 5 Days		After 10 Days		After 15 Days		After 20 Days		After 25 Days		After 30 Days	
	Plain Milk	Peptone Milk	Plain Milk	Peptone Milk	Plain Milk	Peptone Milk	Plain Milk	Peptone Milk	Plain Milk	Peptone Milk	Plain Milk	Peptone Milk
65S	5.1	11.4	5.5	12.7	8.0	17.0	8.2	17.2	9.0	20.1	11.4	20.1
2X	4.8	11.4	5.1	12.9	6.1	13.1	5.0	12.5	5.7	13.3	11.6	15.5
44S	5.5	11.1	4.6	12.7	8.7	14.5	9.8	15.8	12.7	16.2	12.0	17.8
8S	6.6	6.0	4.0	4.8	5.3	5.8	3.7	5.7	3.7	7.0	4.0	7.7
9S	7.6	6.0	4.0	6.1	6.9	8.2	6.0	9.1	7.5	9.2	9.6	9.5
66S	9.2	13.2	9.2	14.7	12.8	19.3	11.6	19.5	15.3	19.5	15.3	24.4
70	5.8	11.4	5.0	12.8	8.1	14.5	8.3	16.2	11.3	17.6	13.0	19.0
14B	6.4	9.8	5.5	12.3	8.3	16.2	9.2	16.6	11.5	16.5	11.8	20.4
90S	6.3	13.4	7.3	15.1	9.2	16.3	9.7	16.0	11.7	17.3	12.7	19.0
96	7.2	14.3	8.3	13.5	10.8	14.4	10.8	13.9	12.9	16.9	15.5	18.0
CK*	3.5	4.1	3.5	4.1	3.5	4.1	3.5	4.1	3.5	4.1	3.5	4.1

*Check.

On glucose agar slants, the organisms grow very well. The characteristic growth is beaded to effuse in appearance. Glucose appears to favor the growth of the group. A good growth is observed in one to four days in glucose broth inoculated directly from a colony, while on the other hand, a litmus milk culture from a similar origin is coagulated only after two to fourteen days' incubation. Peptone added to the milk favors their growth; coagulation and acid production being much more prompt. The acidity produced by the different organisms in milk varies from 0.9 per cent. to 2.5 per cent., calculated as lactic acid.

The rate and amount of acidity produced from a few cultures, growing in plain and in 1 per cent. peptone milk respectively is shown in Table I.

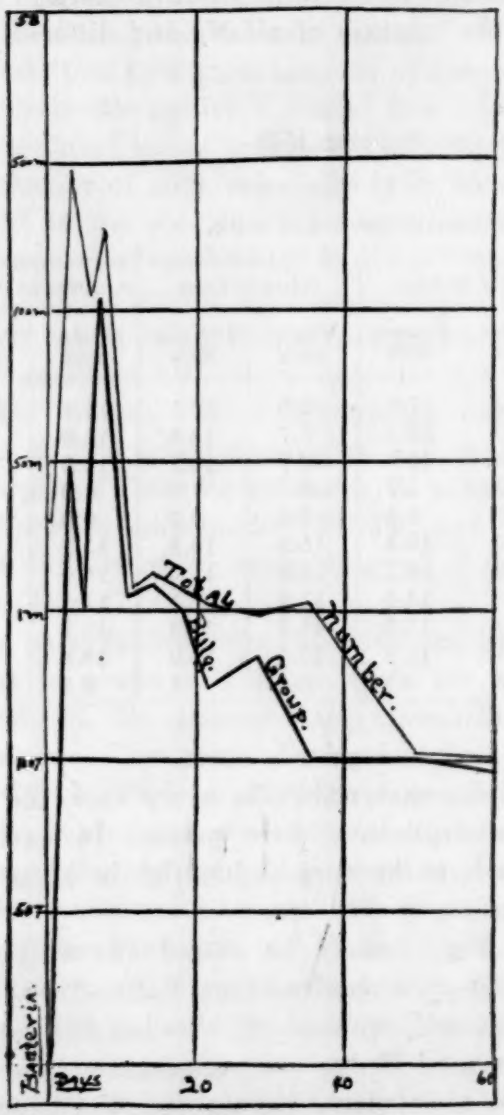
In Fig. 1 may be found curves plotted from the data obtained from kaffir silage. The table is self explanatory, showing the relation of the total *Bulgarian* organisms to the total microbial content throughout the ripening process of the ensilage. The ensilage was considered very good. The acidity[2] as it entered the silo was 0.18 per cent., figured as lactic acid. The final acidity was 2.07 per cent., of which 1.36 per cent. was non-volatile.

[2] The total acidity was determined by the method proposed by Swanson, Calvin and Hungerford, *Journal of the American Chemical Society*, Vol. XXXV., No. 4, April, 1913.

calculated as lactic acid, while 0.71 per cent. was volatile[3], figured as acetic acid. Plain agar was used to obtain the total microbial content. The relation of these two curves to each other compares very favorably with the corresponding curves made from other kinds of ensilage studied.

Fig. 1.

A Comparison of Total Numbers with the Bulgarian Type in Kaffir Ensilage



The presence of this group, in all normal ensilage, in large numbers, at a very important stage of fermentation, together with the fact that their characteristic fermentation is acid production, seem to offer sufficient evidence to support the view that a large part of the acid formed in normal ensilage is the result of their activities.

A more detailed report relating to silage fermentation will appear later.

[3] The volatile acids were determined by the method proposed by Dox and Neidig, *Research Bulletin*, No. 7, Experiment Station, Iowa State College.

O. W. Hunter
L. D. Bushnell
Department of Bacteriology,
Kansas State Agricultural College

THE ANNUAL MEETING OF THE AMERICAN PHYSICAL SOCIETY

The eighty-first meeting of the American Physical Society was held at Columbus, Ohio, December 27–30, 1915. It was the annual meeting and a joint meeting with Section B of the American Association for the Advancement of Science. Six sessions were held for the reading of papers. President Merritt presided, except on Wednesday afternoon, which was devoted to a special program of invited addresses arranged by Section B. Vice-president E. P. Lewis was in charge of this session. At the other five sessions the following sixty-three papers were presented:

"A Mechanical Device for the Rapid Evaluation of Certain Variable Exponential Functions," by Irwin G. Priest.

"On the Value of $\gamma = Cp/Cv$ for Hydrogen," by Karl K. Darrow.

"Deviation of Natural Gas from Boyle's Law," by R. F. Earhart.

"Preliminary Report on the Diffusion of Solids," by C. E. Van Ostrand and F. P. Dewey. (By title.)

"On the Properties of Matter at Low Temperatures," by Jakob Kunz. (By title.)

"Pressures and Critical Lengths in the Collapse of Short Tubes," by A. P. Carman.

"A Photographic Study of the Relative Velocity of Sound Waves of Different Intensities," by Arthur L. Foley.

"A Preliminary Investigation of an Explosion Wave in a Gas," by J. B. Dutcher.

"An Attempt to Detect a Change in the Specific Heat of Selenium with a Change in the Illumination, and also with the Application of an Electric Field," by L. P. Sieg.

"Wind Velocity and Elevation," by W. J. Humphreys.

"A Proposed Physical Method for Reducing Radiant Power and its Luminous Value," by Irwin G. Priest and Chauncy G. Peters.

"The Coefficient of Total Radiation of a Uniformly Heated Enclosure," by W. W. Coblentz and W. B. Emerson.

"A Luminosity Curve Equation and its Application to the Black Body," by E. F. Kingsbury.

"Black Body Brightness and the Mechanical Equivalent of Light," by Herbert E. Ives and E. F. Kingsbury.

"The True Temperature Scale for Tungsten and its Emissive Powers at Incandescent Temperatures," by A. G. Worthing.

"'Color Temperature' Scales for Tungsten and Carbon," by Edward P. Hyde, F. E. Cady and W. E. Forsythe.

"The Infra-red Spectra of the Alkaline Earth Group," by H. M. Randall.

"The Pole Effect in a Calcium Arc," by Henry G. Gale and Walter T. Whitney.

"The Reflecting Power of Alkali Metals in Contact with Glass, as Determined by the Photoelectric Cell," by J. B. Nathansen.

"The Refractive Indices of Hydrogen and Helium on Bohr's Theory," by C. Davisson.

"A Photographic Study of the Diffraction Ring System in the Shadow of a Sphere," by Mason E. Hufford.

Wednesday, December 29, 10 A.M.

"The Ionization Produced by a β-particle," by Alois F. Kovarik and L. W. McKeehan.

"The Rôle Played by Gases in Photo-Electric Discharge," by R. A. Millikan and Wilmer H. Souder.

"The Relation between the Pressure Effect and the Light Effect in Selenium Crystals," by E. O. Dietrich.

"On the So-called Magnetic Rays of Righi," by James E. Ives.

"The Absorption Coefficients of various Metals for High Frequency X-Rays," by S. J. M. Allen.

"The Distribution of Energy in the X-Ray Spectrum of Tungsten and Molbydenum at Constant Potential," by A. W. Hull.

"The Emission Quanta of Characteristic X-Rays," by David L. Webster.

"The Tribo-luminescence of Manganese-Zinc Compounds." With demonstration. By C. W. Waggoner.

"A New Law relating Ionization Pressure and Current in the Corona of Constant Potentials," by Earle H. Warner.

"Arcs in Gases between Non-consuming Electrodes," by G. M. J. Mackay and C. V. Ferguson.

"The Hall Effect and Allied Phenomena in Rare Metals and Alloys," by Alpheus W. Smith.

"Mechanical and Acoustical Impedance, and the Theory of the Phonograph," by A. G. Webster.

"Further Experiments on the Impedance of Conical Horns," by A. G. Webster.

"The Effect of Surface Films on Contact E. M. F.'s," by R. A. Millikan and Wilmer H. Souder.

"A Resonance Method for Measuring the Phase Difference of Condensers," by H. L. Dodge.

"The Magnetic Susceptibility of Oxygen," by W. P. Roop. (Read by E. P. Lewis.)

"An Unrecognized Error in the Measurement of Magnetic Flux," by Arthur Whitmore Smith.

"Unipolar Induction and Absolute Rotation," by E. H. Kennard.

"The Electrical Resistance of Vertically Suspended Wires," by S. R. Williams.

"A Simplified Apparatus for Measuring the Conductivity of Electrolytes," by R. P. Hibbard.

"Measurements of an Electric Current from its Heating Effect," by S. Leroy Brown.

"A Study of the Law of Response of the Silicon Detector," by Louise S. McDowell and Frances G. Wick.

"On the Free Vibrations of a Lecher System IV.," by F. C. Blake and Charles Sheard.

"Constant High Potential for X-Ray Work," by Albert W. Hull.

"Carbon Compression Rheostats," by E. L. Clark.

"On the Theorem that all Action Requires Action at a Distance Somewheres," by E. H. Kennard.

"The Black Body at the Melting Point of Platinum as a Fixed Point in Photometry," by Herbert E. Ives.

"The Luminous Efficiency of the Carbon Incandescent Lamp and the Mechanical Equivalent of Light," by Herbert E. Ives and E. F. Kingsbury.

"The Mobility of Positive Ions," by Henry A. Erikson.

"The Hall Effect and Allied Phenomena in Tellurium," by P. I. Wold.

"A Wehnelt Cathode Ray Tube Magnetometer," by C. T. Knipp and L. A. Welo.

"An Investigation of the Acoustical Properties of the Armory at the University of Illinois," by F. R. Watson.

"New Electromagnetic Phenomena demonstrated by Floating Sand Pebbles and other Non-conductors in Acidulated Water," by J. C. Lincoln. (By title.)

"The Phonotrope, a New Instrument for find-

ing the direction of an Acoustical Ray,'' by A. G. Webster.

''The Propagation of Transverse Waves in a Bar,'' by Louis Thompson.

''The Exceptions to the Law of Dulong and Petit,'' by J. E. Siebel.

''Experiments with Slow Positive Rays,'' by A. G. Dempster.

''Theory of the Free Vibrations of a Lecher System,'' by F. C. Blake.

''Springs of Minimum Weight,'' by Henry C. Lord. (By title.)

''Spectra of Some Halogen Compounds and Phenomena Connected Therewith,'' by Charles Sheard and C. S. Morris.

''On a New Method of using the Reversible Pendulum for the Determination of g,'' by J. C. Shedd.

''The Effect of Absorbed Gases in Photoelectric Emission,'' by Robert J. Piersol. (Read by E. P. Lewis.)

At the special session in charge of Section B on Wednesday afternoon the following program was presented:

''The Dependence of Progress in Science upon the Development of Instruments'' (Vice-presidential address before Section B), by Anthony Zeleny.

''A General Survey of the Field of High Pressure,'' by P. W. Bridgman. Discussion by A. G. Webster.

The Northrup Visible Molecules Apparatus was demonstrated at the close of the session.

At a short business session on Wednesday the result of the mail ballot for officers for 1916 was announced as follows: for president, R. A. Millikan, of Chicago; vice-president, H. A. Bumstead, of New Haven; secretary, A. D. Cole, of Columbus; treasurer, J. S. Ames, of Baltimore; members of council, Irving Langmuir, of Schenectady and G. B. Pegram, of New York; members of editorial board, A. Trowbridge, E. P. Lewis and W. C. Sabine. Several other items of business were transacted.

The registration for the meeting was 158. About one hundred were present at the Physicists' dinner on Wednesday evening. Whether judged by the number and character of the papers presented, by the attendance or by the amount and interest of the discussion following the papers, this meeting was one of the best that the American Physical Society has ever held.

A. D. Cole,
Secretary

THE BOTANICAL SOCIETY OF AMERICA. II

The Evolution of Reproductive Mechanisms in Seed Plants: E. C. Jeffrey and R. E. Torrey.

Mechanisms strictly so called are not numerous in plants. Among them may be classed the annulus which causes the opening of the sporangium in ferns and fern allies, including the cycads. The annulus is obviously a structure of epidermal origin, sometimes showing the presence of stomata. In the seed plants from *Ginkgo* upwards the opening mechanism of sporangia is not primarily of this nature. In the lower Gymnosperms the cryptogamic wood of centripetal development persists strongly, clearly indicating their filiation with the fern series. In the higher Gymnosperms the centripetal or cryptogamic wood becomes merged in the so-called transfusion tissue. The purpose of the present communication is to make clear that the transfusion tissue of *Ginkgo* and the Abietineae obviously furnishes the mechanism for opening the microsporangium. In the higher Conifers as well as in the Gnetales and angiosperms the fiber layer or mechanical system of the anther wall is no longer related to the fibrovascular system. The considerations advanced make it clear that sporangial mechanisms are of diverse origins. In the Cycadales and their allies the fern-like plants, the epidermis supplies the mechanically active layer. From the Ginkgoales upwards the tissues of the fibrovascular system, particularly the vestiges of the cryptogamic centripetal wood known as transfusion tissue, take on the function of providing for the opening of the spore sacks. The sporangium of the lower forms may appropriately be designated ectokinetic since its action depends upon the mechanical action of an external tissue, the epidermis. The sporangium of the higher forms, in which the fibrovascular tissue is primitively related to the mechanically active layer, is appropriately designated endokinetic.

The Comparative Rapidity of Evolution in Various Plant Types: Edmund W. Sinnott.

Given an equal degree of heritable variability, the rapidity with which a plant undergoes evolutionary change depends on the growth-type to which it conforms. Herbs, with their very brief period from seed to seed, accumulate changes much more quickly than do trees and shrubs, with their much longer generations. Local specific and generic types therefore arise most readily among herbs. Herbs occur in a much smaller number of

families than do woody plants, but their number of species per family is greater. A study of the rapidity of evolution in these two types throws light on the antiquity of the angiosperms.

Experimental Evolutionary Investigations with the Genus Drimys: E. C. JEFFREY AND R. D. COLE.

The genus *Drimys* of the Magnoliaceae has long excited interest as a dicotyledon entirely without the vessels, which are such characteristic features of wood structure in the angiosperms as a group. The value of experimental work in connection with evolutionary problems has been particularly emphasized in recent years and there can be no doubt that experimental studies on the part of those who are sufficiently acquainted with the history and morphology of plants to interpret the meaning of the structures experimentally produced, is of great value. Experimental investigation has in the past few years thrown great light upon the evolutionary history of the conifers and has begun to be applied to the elucidation of the course of evolution to the dicotyledons. The present communication is for the purpose of calling attention to the highly interesting fact that structures resembling vessels can be recalled in *Drimys* as a result of experimental procedure. It has not yet been found possible to bring about the return of such structures in the stem, but vessels are readily recalled in that most conservative of all plant organs, the root. The experimentally recalled vascular structures resemble those found in the Magnoliaceae as a whole. The consequence of this demonstration is of considerable evolutionary importance on account of the primitive position often accorded to the Ranales and in particular to the Magnoliaceae. It seems clear that *Drimys* can no longer furnish an argument in favor of this view since the simplicity of wood structure, resembling that of the Conifers, is not primitive but clearly the result of reduction.

Is the Vesselless Secondary Xylem of Certain Angiosperms a Retention of Primitive Gymnosperm Structure? W. P. THOMPSON AND I. W. BAILEY.

Vessels are entirely absent in the xylem of *Tetracentron, Trochodendron* and *Drimys*. Vestiges of vessels do not occur in the root, seedling, young stem, petiole, traumatic tissue, and other regions that have been considered to be retentive of ancestral characters. The form, structure and arrangement of the tracheids of the xylem closely resemble those of gymnosperms, and there seems to be no valid reason for not considering the three genera primitive as far as their xylem structure is concerned. The wood-parenchyma is "diffuse" in *Tetracentron, Trochodendron* and *Drimys winteri*. In *D. colorata* and *D. axillaris* it shows transitions from diffuse to banded and terminal. The distribution of parenchyma in these three genera makes it seem very improbable that the "terminal parenchyma" of the Magnoliaceae originated through reduction from the "vasicentric" condition. There appears to be no reliable evidence to indicate that the Magnoliaceae and allied families are forms that have become highly specialized through "reduction" from advanced types of Angiosperms.

Some Observations upon the Secondary Xylems of Gymnosperms and Angiosperms: W. W. TUPPER AND I. W. BAILEY.

From measurements of tracheid-lengths and wood-fiber-lengths taken from the secondary xylems of a large number of gymnospermous and angiospermous woods, respectively, the authors have confirmed and supplemented the work of Sanio, De Bary, Record and others, which show a very great difference between the lengths of gymnospermous tracheids, on the one hand, and the tracheids and wood-fibers of the dicotyledons, on the other.

The former elements average more than twice as long as do those of the dicotyledons of about the same age, with the very striking exception of the vesselless angiosperms, *Tetracentron, Trochodendron* and *Drimys*, which seem to have the typical gymnospermous length of wood elements.

Climaxes and Climates of Western North America: FREDERICK E. CLEMENTS.

Each climax vegetation is regarded as a developmental unit, and hence is designated as a formation. The vegetation of the continent is consequently made up of a number of climax formations, each with a development and structure more or less peculiar to itself. As a result, it becomes desirable to distinguish two kinds of units, developmental and climax, the one typical of succession, the other of the final adult condition of vegetation during a particular climatic period. Each climax is coextensive with its climate, and is in fact the indicator of the latter. Climaxes, moreover, exhibit a phylogenetic sequence due to differentiation and shifting in the face of a climatic crisis, such as glaciation. Such a shifting is recorded in the zones, such as are characteristic of

the Rocky Mountains, where five formations occur, namely plains grassland, woodland, montane forest, subalpine forest and alpine grassland. Finally, while each climax is more or less stable during a climatic period, the transition between two climaxes bears eloquent testimony to the shiftings of dominants and subdominants produced by minor climatic cycles.

A Photometer Battery for Habitat Analysis: F. E. Clements.

A series of photometers has been devised for the comprehensive study of the intensity and quality of light in the various kinds of habitats. Those used to measure light intensity are based upon the Bunsen-Roscoe photographic method. The simple photometer is designed for use on reconnoissance trips or in connection with a base station. Its most desirable form is the stop-watch photometer in which the personal factor in timing is eliminated. It is further modified into the water photometer for securing light readings at various levels in ponds and lakes. The recording photometer or selagraph consists essentially of a clock mechanism and a photographic shutter, permitting hourly exposures for a week without attention. The electric spectro-photometer is a compact instrument for determining the light quality in forest and thicket or at different altitudes, without the use of a tripod.

What is Tolerance of Forest Trees? George P. Burns.

The Root Growth of Forest Trees: W. B. McDougall.

Direct observations were made on the roots of *Acer saccharinum, Tilia americana, Carya alba* and *Quercus macrocarpa,* nearly every week during the growing season and occasionally during the winter, from April, 1914, to September, 1915.

Growth begins in April, the exact time varying with the season. It ceases in autumn or early winter when the soil becomes too cold for absorption. In 1914 there was a resting period of about five weeks in July and August when no root growth occurred. During this time the soil was very dry. In 1915 there was no dry season and no resting period. No attempt has been made to determine accurately at what temperature growth ceases or how much soil moisture is necessary for growth, but it is believed that enough has been done to establish the following general facts: (1) The root growth of forest trees begins as early in spring as the soil becomes warm enough for absorption, and ceases in autumn when the soil becomes too cold. (2) There is not necessarily a summer resting period. (3) When there is a summer resting period it is due to a lowering of the water supply, and not to any inherent tendency toward periodicity.

The Marine Algae of Beaufort, N. C., and Adjacent Regions: W. D. Hoyt.

Contrary to the belief that the Atlantic coast from Long Island to Florida is barren of Algae, 138 species and varieties have been found, all except 10 of these occurring at Beaufort. Of the total number, 130 have been obtained in sufficient amount for determination. There are represented 83 genera and 34 families, including all four divisions of Algae. The identified species are distributed as follows: Myxophyceae, 10, 7.7 per cent.; Chlorophyceae, 25, 19.2 per cent.; Phaeophyceae, 27, 20.8 per cent.; Rhodophyceae, 68, 52.3 per cent. Because of its intermediate position, Beaufort has an algal flora of unusual interest, 20 genera and 41 species reaching here their northern known limit on our coast, while 3 genera and 9 species reach here their southern known limit. Eighteen species new to North America have been found, 8 of these being hitherto undescribed. The seasonal differences are strongly marked in the flora of Beaufort harbor, only 12 species having been found throughout the year and 4 others in both spring and summer. The appearance and disappearance of the seasonal floras are strikingly coordinated with the observed temperature of the water. Measurements of the light show that this penetrates to very slight depths. Correlated with this fact, the algae seldom extend to a depth greater than 90 cm. below the low tide line. With the exception of a very few species, no Algae are found in summer above the low-tide mark. Several submerged coral reefs lying offshore offer extremely interesting conditions and a very interesting flora resembling that of subtropical regions.

Endemism in the Flora of the Vicinity of New York: Norman Taylor.

Endemism, as found in the flora of the vicinity of New York, does not appear to be a criterion of antiquity, for many endemics are very recent. Neither are the endemics prevailingly woody, for only 4 woody forms out of a total endemic element of 22 species disproves this contention. Nor does antiquity or woodiness prevail among the species of endemic genera. Rarity or commonness does not

appear to have much to do with the age of our local endemics, for it has been shown that some of our most widely spread species are among the newest in point of origin. "Relict endemism" accounts for 5 of the local species which are shown to be outpost survivals of a preexisting flora. All of these are species of endemic genera; only one is woody, although these are probably the most ancient of all our endemics. Generic and specific instability seems to account for the great majority of our endemics, 14 in all. These species are all shown to belong to genera that dwindle, or to be related to species that are on or near their limits, in the local region. Further support of this view is given by the proportion of species in eastern North American genera containing endemics, to the number of species found in the rest of the country and abroad. Only 20 per cent. of our whole vegetation finds its limits in the area, but much over half of our total endemics belong to genera that dwindle, or are related to species that find their limits, here or very near here. "Habitat endemism," where a species seems to have been thrust off from a well-known and widely dispersed form, into a totally different habitat from that of the supposed progenitor, seems to account for two of our local endemics.

On the Occurrence of Pinus Banksiana Lamb. in the Driftless Area of Southeastern Minnesota: C. O. ROSENDAHL AND F. K. BUTTERS.

The main pine forests of Minnesota occur to the north of a line drawn from the northwestern corner of the state to the Wisconsin boundary, about latitude 45° 30′. *Pinus Strobus* L. is found in a number of isolated localities down through the Mississippi River valley to northern Iowa, but outposts of *Pinus Banksiana* are very unusual. In June, 1915, a grove of jack pine was found near Rushford in the Root River valley, near the southeastern corner of the state. This is about one hundred and eighty miles south of the previously known limit in this state and at least eighty miles from the pine areas of central Wisconsin. It lies inside the driftless area and the indications are that it is a natural relict, probably from glacial times. The largest trees are estimated to be from fifty to sixty-five years old, thus dating back a few years beyond the oldest settlement of the region. Associated with the pines are a number of species which occur typically in the jack pine forests. Among those noted the following appear to be of special signficance: *Oryzopsis pungens* (Torr.) Hitchc., *Carex siccata* Dewey, and *Vaccinium pennsylvanicum* Lam. The grove is located on a very sandy, steep, north-facing hillside which is built up from disintegrating paleozoic sandstones.

The Distribution of Quercus alba L. in the State of Minnesota: F. K. BUTTERS AND C. O. ROSENDAHL.

The white oak, *Quercus alba* L., occurs in southeastern Minnesota, extending to a point about thirty-five miles northwest of Minneapolis and somewhat farther due north of that city. It is local in its distribution, but where it occurs it is often very abundant. The explanation is that, at least in the climate of Minnesota, it is exacting as to its soil requirements and flourishes only on well-drained, non-calcareous soils which are moderately retentive of moisture. Such soils are the residual clays of the unglaciated region, the less calcareous portions of the loess, and the sour red clays frequently found in that part of the Wisconsin glacial drift which came from the northeast, and on all these soils the white oak abounds. The gray glacial clays from the northwest which underlie the main deciduous forest region of central Minnesota are generally too calcareous for this species, and it has succeeded in penetrating that region for only a few miles and in a few favorable localities. Near the middle of the state are some tracts of red clay similar to those which occur farther south and east, but no white oak has reached them, its place being taken by a form of *Quercus macrocarpa* Michx. It is suggested that the region of calcareous clays has acted as a sieve or selective barrier, allowing one of these species to migrate freely while greatly retarding the progress of the other. Culture experiments support the evidence derived from the distribution of the species. In four years, a seedling white oak grown in fine clean quartz sand grew about four times as large as a seedling of the same species planted in sand containing five per cent. of chalk, while bur oak seedlings grew almost equally well in the two soils.

The Patanas of Ceylon: H. A. GLEASON.

The patanas, or natural grasslands of Ceylon, occupy extensive areas in the southern end of the island, mostly at high elevations. They are usually located in valleys among the mountains, and at their upper margin come in contact with the subalpine forests. They occupy various types of soil, and receive various amounts of rainfall, depending on their location in reference to the mountain

ranges. The boundary between the patanas and the adjoining forests is remarkably sharp. The origin of the patanas is obscure, but their perpetuation is due entirely to the fires which sweep over them annually. Near plantations where the fires are excluded, a thicket association, characterized by *Rhododendron arboreum* and *Hypericum mysorense,* develops immediately, and is followed by the regular subalpine forest.

Observations on the Revegetation of the Katmai District of Alaska: Robert F. Griggs.

Under the auspices of the National Geographic Society the author has undertaken the investigation of the return of vegetation to the country devastated by the eruption of Mt. Katmai in 1912. Where the deposit of ash did not exceed one foot in depth, as, for example, at Kodiak, vegetation has made a most surprising recovery so that the grass and berries for which the district is famous, are finer than ever before. The new growth, however, is made up exclusively of surviving plants. Where for any reason the original plants did not persist the ground is nearly always as bare as when the ash first fell. Except in sheltered situations the ash is picked up by the wind, giving rise to a severe sand blast and forming great dunes which give little opportunity for the start of new seedlings. In more sheltered situations seedlings have started, but as yet form no important element in the vegetation, for their growth is very slow. Near the volcano the deposits were deeper; almost all vegetation was destroyed, leaving the country a bare desert. But some of the herbage persisted in sheltered nooks where the ash was quickly washed off the surface before the plants were suffocated. Such oases are, however, entirely insignificant in the barren landscape. Except for sporadic accidental instances, revegetation has not yet begun on the mainland.

The Cactus Columns of the Bad Lands: Raymond J. Pool.

Few cases are on record of cactus species serving as soil binders in opposition to the erosive forces of the environment. It appears that the root systems of cactuses are mostly characterized by the presence of shallow but more or less extensively spreading horizontal roots. Such plants are ordinarily rather easily uprooted. However, several instances have been noted in the Bad Lands of northwestern Nebraska of certain species of *Opuntia* which have a root system considerably deeper and less widely spreading than most cactus species. Furthermore, cushions or colonies of this species resist erosion to a surprising degree. The soil surrounding such cushions has been weathered away, leaving erect columns of the soil capped by the closely aggregated cushions or colonies of the cactus. These columns are sometimes more than ten feet high and vary in diameter from two feet to ten feet.

Modern Changes in the Prairie Groves of Iowa: B. Shimek.

It is often asserted that since the cessation of prairie fires the groves in the prairie region, including Iowa, have extended beyond their earlier limits. So far as Iowa, at least, is concerned, this is disproved by the testimony of old settlers, but especially by the records of the original government surveys. Several specific cases are presented in detail and illustrated by maps. The condition of the prairie groves is discussed with special reference to changes of an ecological character which are taking place and in which fire has played an unimportant part. The most marked change which is noticed is the increased density of both forest and undergrowth in the undisturbed groves. Incidentally this weakens or destroys one of the strongest supports of the view that fires caused the treelessness of the prairies. The results achieved in artificial tree-planting are also discussed.

Illustrating the Prickly Pears and Their Allies: David Griffiths.

In connection with the investigation of cactus conducted by the U. S. Department of Agriculture, distinguishing records of the species and varieties handled soon became imperative. In a group whose vegetative characters have in the past been relied upon mainly for taxonomic purposes, the task of distinguishing and depicting accurately the species dealt with in field tests and breeding investigations has been decidedly difficult. Some years ago it was decided to illustrate the species as accurately as possible. A living collection of 2,400 numbers of *Opuntia* has been accumulated at Chico, California. These are grown under field and sash house conditions and at present form the basis of the work. Characteristic portions of the plants, *i. e.,* old and young joints, flowers, buds and fruits are photographed to scale. Where the objects are large and the details complicated, as in the case of the joints, these photographs are used as a base for the water-color painting. In the case of fruits and buds, especially, they are outlined by the use of a camera lucida adapted to macroscopic work. Every effort is made to pre-

pare illustrations which are scientifically accurate. The cameras attend to the facts of form and Mr. L. C. C. Krieger, who has had varied experience and training in plant illustrating, attends to the remainder of the work about as successfully.

Relation of Catalase and Oxidase to Respiration in Potato Tubers: CHAS. O. APPLEMAN.

Respiration in potato tubers is not only greatly accelerated by various artificial treatments, but is subject to fluctuations under natural conditions, such as greening and sprouting. The rate of respiration varies in different parts of the same tuber and tubers of different varieties. The modification of the intensity of respiration in tubers under such conditions was determined and at the same time measurements were made of both the oxidase and catalase activity in the juice. The data seem to justify the following conclusions: (1) The oxidase content in potato juice gives no indication of the intensity of respiration in the tubers. In other words, there is no correlation between oxidase activity and the rate of respiration in these organs. The author does not disclaim any rôle of the demonstrable oxidases in respiration, but they certainly are not the controlling factor in regulating the rate of respiration in potato tubers. (2) Catalase activity in the potato juice shows a very striking correlation with respiratory activity in the tubers.

Lipolytic Action in Germinating Teliospores of Gymnosporangium juniperi-virginianae: G. H. COONS.

Teliospores from mature telial horns of *Gymnosporangium juniperi-virginianae,* were ground with fine sand and a small amount of water extract obtained. This extract when mixed with some neutral fat (olive oil, castor oil) colored violet by litmus, caused no change in color even after standing over night. When columns in which the spores were germinated were similarly ground and an extract of approximately the same amount obtained, this was found to produce acid from neutral fats. Reddening of the litmus which could readily be detected by comparison took place in two to four hours. In these experiments chloroform was used as an antiseptic. The experiments were repeated with changes in the technique. Telial horns were cut from several large galls. These were divided into three portions. One portion was left dry, the second was placed in water at approximately 80° C. to kill the teliospores, while the third was soaked in tepid water until the jelly-like telial columns were swollen. The water in which the third portion was soaked was then poured over the heated sori. This was an attempt to balance the bacterial and fungal flora of these two portions. The second and third portions were then drained and kept under similar moist conditions until the next morning. The columns were then ground with a small amount of water and a few cubic centimeters of water extract obtained. Tests were made with neutral fats colored violet with litmus. The third portion was the only one to give an extract which had the power to produce acid from the fats. In these tests small test tubes kept in the incubator at 37½° C. were used. Potassium cyanide was used as an antiseptic. When the active extract was boiled for a few moments it gave a negative result in acid production. The amounts of extract obtained were so small that no attempt was made to precipitate with alcohol. When oil which had been acted upon by the extract from the germinated teliospores was tested, glycerin was found to be present. None was found in the oil untreated. The conclusion seems justified that in germinating teliospores, lipase is present. This places the rust fungi in the long list of organisms now known to possess lipase. Attention may be called to the rôle of lipase in germination. The rust spores are especially rich in oils and in the short period required for germination one or more basidia, larger than the spore itself, are sent out. In addition two or more spores are formed on the basidium. The conversion of the globules of oil into soluble products easy of transport, seems to be a factor in this rapid germination process.

The Action Upon Soil Nitrogen of Certain Crops: K. F. KELLERMAN AND R. C. WRIGHT.

Twelve representative field crops were grown alone and in certain combinations in large galvanized iron buckets holding 100 pounds of soil. When two species of plants were grown in association, one half the number of plants of each species was used as when each was grown separately. Crops were all grown to maturity and harvested close to the surface of the soil. With the growth of millet, corn, Kafir corn and oats, practically all the total nitrogen removed from the soil was recovered in the crop. With wheat, barley, rye and sugar beets, all the nitrogen removed from the soil was not recovered in the crop. Also when hairy vetch, red clover and field peas were grown there was a distinct loss of nitrogen. With the growth of soy beans alone of the legumes, there

was a fixation or increase in nitrogen over that removed from the soil. When grown in association there was a loss of total nitrogen with the following combinations: barley and peas, rye and vetch, rye and peas, rye and clover, Kafir corn and peas, Kafir corn and clover, corn and millet, and corn and oats. There was an increase in nitrogen with the following combinations: barley and vetch, barley and clover, oats and vetch, oats and peas, oats and clover and Kafir corn and vetch.

The quantities of nitrate nitrogen remaining in the soil were comparatively low after harvesting millet, corn, Kafir corn and beets; and somewhat higher after clover, vetch, soy beans and peas; and still somewhat higher after oats, wheat, barley and rye.

A Physiological Study of Certain Strains of Fusarium oxysporum and Fusarium trichothecioides in their Causal Relation to Tuber-rot and Wilt of Solanum tuberosum: Geo. K. K. Link.

Certain strains of *Fusarium oxysporum* and *Fusarium trichothecioides* can produce both tuber-rot and wilt of the Irish potato. The wilt is induced by destruction of the root system and by clogging of the xylem elements in the stem and is, in mild cases, marked by such symptoms as discoloration of leaves, curling and rolling of leaves, and production of aerial tubers. Under field and storage conditions *Fusarium oxysporum* is probably more responsible for wilt than is *Fusarium tricothecioides,* and *Fusarium trichothecioides* the more responsible for tuber-rotting. This may be explained in part by the fact that the optimum and maximum temperatures of *Fusarium oxysporum* are higher than those of *Fusarium trichothecioides. Fusarium trichothecioides,* however grows well at 8°–10° C., while *Fusarium oxysporum* does not. *Fusarium oxysporum* also has a more rapid, superficial and spreading habit of growth than has *Fusarium trichothecioides.* Both organisms possess a truly striking cosmopolitan ability to use the most diverse carbon materials as carbon sources in their metabolism. *Fusarium oxysporum,* however, is more cosmopolitan in its ability, and can utilize materials more readily than, though not so completely as, does *Fusarium trichothecioides. Fusarium oxysporum* also is less subject to inhibition in growth and intoxication than is *Fusarium trichothecioides.*

Some Factors Determining the Presence of Fat as a Food Reserve in Woody Plants: Edmund W. Sinnott.

Reserve fat occurs most abundantly in those woods where the rays and parenchyma cells are comparatively thin-walled and well provided with pits, and is particularly well developed in the cells immediately adjacent to the vessels. It is practically absent in species with thick-walled, slightly pitted parenchymatous tissue. These facts suggest that the occurrence of fat in wood and its distribution there may depend on the ease of diffusion of some fat-forming ferment from the vessels through the rays and parenchyma. Experiment shows the presence of a fat-splitting ferment in the leaves and bark, which varies greatly in amount according to species and season, but which is in general most abundant in the spring in those species where reserve fat was most abundant in winter. It is suggested that perhaps this fat-splitting ferment (lipase) may here be reversible in its action and that during the late summer and fall it may be diffused downward through the wood and bast, converting into fat the food reserves to which it has access.

The Influence of the Medium upon the Orientation of Primary Roots: Richard M. Holman.

In this paper were considered the explanations offered by Hofmeister, Sachs, Elfving and Nemeč for the difference in behavior of primary roots growing in air and in earth when displaced from the normal perpendicular position. The author's experiment indicates that the failure of roots in air to bend downward after the autotropic flattening of the primary geotropic curvature is not due to absence of contact stimulus as Sachs suggested, nor to a change in the geotonus of the root as Nemeč's results seem to indicate. By the use of media whose resistance to penetration by the root tip could be widely varied, roots were caused to behave very nearly as in air or in the same manner as in earth, according as the medium was loose or considerably compressed. The authors' experiments indicate that the effect of the medium is primarily if not exclusively mechanical. The resistance offered by the medium to the advance of the downward curved tip of a root which has flattened its primary curvature tends to passively depress the root and in this manner the root is enabled to complete the geotropic reaction in media which offer appreciable resistance to the advance of the tip. *Vicia faba, Lupinus albus* and *Pisum sativum* were the principal species employed, although many other forms behaved similarly. Secondary roots of the three species men-

tioned behaved in a manner similar to the primary roots, reacting more promptly in media offering considerable resistance to penetration than in looser media. In the case of secondary roots the lack of complete permanent georeaction in moist air, as contrasted with prompt and complete curvature in earth, seems to be due to the mechanical cause mentioned above in connection with primary roots.

On the Permeability of Certain Non-living Plant Membranes to Water: F. E. DENNY.

A report of a series of experiments with plant membranes in which quantitative measurements were made of their permeability to water. Membranes used were seed coats of peanut, cycad, almond, English walnut, pumpkin, bulb-scale of onion, etc. Measurements were made in an osmometer so constructed as to detect the passage through the membrane of very small quantities of water, and to keep the physical factors such as temperature and concentration of solution constant. In each test the exact area of membrane used was known. Results are reported showing the temperature coefficient for a rise of 10° C., and showing the permeability of the membranes as affected by the concentration of the bathing medium, direction of flow through membrane, and as influenced by certain chemical constituents of the membrane.

Influence of Temperature on the Moisture Intake of Seeds: CHARLES A. SHULL.

A critical analysis of the data obtained as to the rate of moisture intake by seeds possessing semipermeable coats (*Xanthium*) at various temperatures from 5 degrees to 50 degrees C. shows that the curve of intake is by no means so simple as was assumed by Brown and Worley for barley seeds. The curves of intake are essentially the same in character in certain seeds used, whether semipermeable coats are present or not, but differ in steepness according to the kind of seed used. The temperature coefficient for the rate of intake is decidedly lower than the Van't Hoff coefficient for chemical processes, and considerably lower than the values obtained with barley seeds. Moreover, plotting the logarithms of hourly rate of intake against temperatures does not yield straight lines. It is evident, therefore, that the conclusions reached by Brown and Worley are not applicable generally.

Some Experiments on Galvanotropism: C. H. FARR. (Introduced by R. A. HARPER.)

The Structure of the Bordered Pits of Conifers and Its Bearing upon the Tension Hypothesis of the Ascent of Sap in Plants: I. W. BAILEY.

The tension hypothesis of the ascent of sap in plants, as interpreted by Dixon, postulates continuous columns of water that are entirely free from bubbles (0.02 mm. or more in diameter) of air or gas. However, even if continuous columns of water are present throughout the year, which has not been demonstrated conclusively, it remains to be shown how high tensions can arise and be maintained in the tracheids of tall trees. The pit membranes of Conifers are not entire septa, and are not impervious to undissolved gases and solids, as has previously been supposed to be the case. They are porous or sieve-like in structure, and the surface tension of the sap, in the sieve-like pit membranes of various Conifers, is not sufficiently great to prevent the penetration of air or gas, under the tensile strains that are supposed, by Dixon, to occur in tall trees.

H. H. BARTLETT,
Secretary

SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 546th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, December 4, 1915, and called to order by President Bartsch at 8 P.M. with 55 persons present.

On recommendation of the council Dr. R. W. Shufeldt, Washington, D. C., and Arthur deC. Sowerby, Tien Tsin, were elected to active membership.

On recommendation of the council the following resolutions were read and adopted:

WHEREAS: Dr. George M. Sternberg, former Surgeon General of the U. S. Army, a distinguished worker in the biological sciences as applied to medicine, long time an active member of the Biological Society of Washington and its president during the years 1895 and 1896, has passed from this life, therefore be it

Resolved: That the Biological Society of Washington keenly regrets his death and offers its warmest sympathy to Mrs. Sternberg, and will always be grateful to his memory for the important part which he took in the affairs and discussions of the society and for the distinction which his eminent name adds to its list of past presidents.

Signed L. O. HOWARD,
FREDERICK V. COVILLE,
PAUL BARTSCH

Under the heading Brief Notes, Exhibition of Specimens: Dr. O. P. Hay exhibited the skull of a walrus from the southern Atlantic coast of the United States and called attention to other specimens of walrus from localities now far south of its present range. It was Dr. Hay's opinion that the walrus had followed the retreating ice sheet northward. Dr. L. O. Howard called attention to the cluster-fly (*Pollenia rudis*), an insect resembling the house-fly but collecting in houses in autumn and leaving a yellow stain when crushed. Its life history was unknown until recently a foreign entomologist has shown that the larvæ are parasitic in earthworms in France. Dr. Howard is having large numbers of earthworms examined for such larvæ, but so far without success. He hoped that any one finding any grub parasitic in earthworms would communicate with him.

The first paper of the regular program was by Dr. Charles H. T. Townsend, "Identification of the Stages in the Asexual Cycle of *Bartonella bacilliformis*, the Pathogenic Organism of Verruga, and their Bearing on the Etiology and Unity of the Disease." The author finds that the complete asexual cycle of *Bartonella* can be interpreted from the figures and descriptions published up to April, 1913, and prior to the inception of the verruga work of Dr. R. P. Strong of the Harvard School of Tropical Medicine, and his associates. The six identifiable stages in these figures and descriptions are as follows:

I. *Early schizonts*—Gastiaburú & Rebagliata, Sept., 1912, in liver and eruption-tissue (eruptive phase).

II. *Maturing schizonts*, III. *Early merozoites*, IV. *Elongated merozoites*—Mayer, Rocha-Lima & Werner, April, 1913, in vascular endothelial cells of eruption-tissue (eruptive phase).

V. *Immature gametes*—Darling, 1911, in blood (fever phase).

VI. *Mature gametes*—Barton, 1905, in blood (fever phase).

The second and last paper of the program was by A. A. Doolittle "The Mississippi River Dam at Keokuk, Ia.; Its Effect upon Biological Conditions, especially those of the Plankton." Mr. Doolittle said:

The Bureau of Fisheries has been examining the new conditions caused by damming the Mississippi River at Keokuk, Ia., to develop electric power. The level of Lake Cooper, as the impounded waters are called, reaches northward for 54 miles, and must be maintained between 34 and 40 feet above 0 of the river gauge at Keokuk. In the lower portion of the lake the gorge of the Des Moines Rapids and its tributaries are filled. In the middle portion much island and farm land with standing forests are inundated. Water Persicaria is becoming established here. In the upper portion levees protect the threatened farm lands, which are kept drained by pumping stations.

There are present the usual characteristics of a river-lake: increased regularity of water stages, decreased current, decreased turbidity, establishment of aquatic plants. The most obvious and immediate effects, biologically, are, destruction of the famous mussels of the rapids, and interference with the migration of fish. Plankton is greatly increased; zooplankton in the Entomostracan species *Moina micrura, Diaphanosoma brachyura* and *Cyclops viridis*, phytoplankton species in *Converva, Anabaena, Clathrocystis*. Above the influence of the dam 50 Emtomostracan individuals, more or less, were present per cu. yd. throughout the summer. At Keokuk there were 1,500 in July, 270,000 in August, and 1,500 in early September, averaging about 10,000 per cu. cm. Green Algae was present in traces in the river proper; at Keokuk 0.14 cu. cm. in July, 29 cu. cm. in August, and 5 cu. cm. in early September. Blue Green Algae increased from traces in July to 2.6 cu. cm. in August and September at Keokuk. The river below the dam was enriched upwards of 100 times in mid-season. In weedy waters heavy bodied Entomostraca abounded; *Sida Scapholeberis, Simocephalus*, with a maximum of 178,000 individuals per cu. yd. whose volume was 23 cu. cm. Streams and sloughs filled from the lake ripened earlier than the lake, and maintained about 50,000 lake species of Entomostraca per cu. yd. Self-fed tributaries usually had plankton differing from that of the lake, sometimes Protozoa (*Euglena*) dominant, or Rotifers (*Asplanchna*), or their own Entomostracan forms. These could be traced into the lake, but they did not persist there. It is evident that there is a vast increase of fundamental food for some species of fish or their young. The discussion was illustrated with map, diagrams and slides showing conditions existing in the summer of 1914.

The paper was discussed by the chair, and by Messrs. Coker, Marsh and William Palmer.

The society adjourned at 10.10 P.M.

M. W. Lyon, Jr.,
Recording Secretary